Vol. 13 No. 4 OCTOBER, 1959

# BRITISH JOURNAL OF PREVENTIVE & SOCIAL MEDICINE

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LONDON
**BRITISH MEDICAL ASSOCIATION**
TAVISTOCK SQUARE, W.C.1

YEARLY SUBSCRIPTION (4 NUMBERS) £3 U.S.A. $10.00 SINGLE NUMBER 17s. 6d

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Fluhmann, C. F. (1936). *Amer. J. Obstet. Gynec.*, **31**, 573.
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*Brit. J. prev. soc. Med.* (1959), **13**, 163–174

# STATISTICAL ANALYSIS OF SUICIDE AND OTHER MORTALITY RATES OF STUDENTS

BY

R. G. CARPENTER

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There has been a good deal of interest in cases of suicide among students since Parnell (1951), Parnell and Skottowe (1957), and Rook (1959) have published papers describing high suicide rates among Oxford and Cambridge undergraduates. *The Times* (1959) drew attention to the fact that, as these studies are based on few cases, the suicide rates given may vary a good deal by chance. The following study, based on the figures given in Rook's paper, is an attempt to evaluate the statistical significance of the incidence rates found at the different Universities. The study also considers briefly other forms of mortality among students. No attempt is made to discuss the implication of the findings.

## Material

Deaths of Cambridge Undergraduates.—Unless the General Register Office publishes figures, it is not easy to find out what mortality is occurring in a particular group of people. Since the University Health Service started in October, 1948, note has been taken of the deaths of undergraduates, and a careful watch has also been maintained on the three or four newspapers in which such deaths would most probably be reported.

Further, in 1958, a search was made by the Cambridge Medical Officer of Health of the records of deaths registered in the city, and the details of all deaths of university students were abstracted. The search started from the present and went back, with the exception of 2 years, as far as the beginning of the academic year 1923–24. Newspapers were scanned to cover the two years in the 1930s for which records were not available.

Finally the records held by the University Registry of all students who had failed to complete their course of study were searched. Occasionally these records showed that the student's studies had been terminated by death. Such cases were noted when they occurred after October, 1923. In this way a few deaths that had happened in the vacations before October, 1948, were found, but the records in this respect were not complete.

If there was any uncertainty about the certified cause of death, the death certificate was consulted. It was also possible, through University Health Service records, from attendance at, and reports of inquests, and from other sources, to obtain the circumstances of death and other information.

*Deficiencies due to the Methods of Collecting the Data.*—The data on suicides among Cambridge undergraduates which were collected during the last 10 years are probably complete. Searching the records of deaths certified in the city did not bring any cases to light that had not already been noted, nor did the search of the University Registry records. The type of case that might have been missed would be a student who was admitted to a mental hospital other than in Cambridge, and who committed suicide while undergoing treatment. Such a case might not attract the attention of the press, and the death would probably be registered at the student's home address and not in Cambridge.

Before 1948 we can be certain of knowing only about deaths that occurred in Cambridge. This will cover most cases of suicide occurring in term time but not necessarily all. For example, cases are known to us of students who left Cambridge suddenly and committed suicide a few days later. In such cases the death certificate would show the temporary place of residence at the time of death.

The University Health Service can also be fairly sure of knowing about most climbing and motor accidents that have befallen students in the last 10 years, but a death due to an accident at home or while in temporary employment might have escaped notice.

Information about the number of deaths due to disease is less certain. Few are known, but students are a favoured class and few are to be expected. Some of the deaths which occurred outside Cambridge are unlikely to have attracted press attention, and so might easily have been missed.

Our knowledge of deaths from causes other than suicide is so limited in the period before 1948 that, apart from the study described in the next section, they have not been included in this analysis.

It will be clear from the above description of the way the data have been collected that, while some deaths may have been missed, there is no possibility that deaths otherwise certified have been accidentally included as suicides.

CONSISTENCY OF THE VERDICTS.—The circumstances in which the death occurred were scrutinized to see if the verdicts had been consistent over the years. The data were found to be entirely satisfactory in this respect with the exception of one verdict on an unusual case in the 1930s. Consistency requires that, although the cause of death in this case was brought in by the coroner as accident, it should be counted as a suicide for the present purpose. This has been done, but any effect is negligible.

THE POPULATION AT RISK.—This comprises the total undergraduate population of the University. These data based on the lists of Resident Members of the University have been recorded annually for many years in the *Cambridge Review* (1923 to 1958). A check of the 1951 list showed it to be correct to within 2 per cent.

DATA FOR COMPARISON.—The Registrar General's Statistical Reviews of England and Wales from 1921 to 1956 (Pubd 1923–1957) give suicide rates for England and Wales by age and sex for the population as a whole. In addition, the Registrar General's Decennial Supplements for 1921, 1931, and 1951 dealing with Occupational Mortality (1927a, 1938, and 1957) give details of mortality due to various causes, including suicide, by social class, age, and sex. In these Supplements the deaths of students are unfortunately grouped with those of other persons not gainfully occupied. However, the Registrar General kindly provided a table comparable to those in the 1951 Supplement showing the mortality rates for students due to accidents, suicide, and all other causes of death, by age for males and for all ages for females. It is a pleasure to acknowledge the very ready co-operation of the General Register Office. National statistics given in this paper come from, or have been calculated from, figures from these sources and from the reports on the 1921, 1931, and 1951 Censuses (Registrar General, 1927b, 1950; General Register Office, 1958). These statistics are given without further reference as to the source.

Finally, it should be noted that a student is defined by the General Register Office as anyone receiving whole-time education. Persons receiving part-time education, apprentices, and those training to be nurses are excluded.

## ANALYSIS

The national suicide rates show important sex differences. Also, the material relating to suicide for women students is very much more limited than that for men. The following analysis is therefore confined to males in the first instance, and such findings as there are for females are then briefly presented.

SUICIDE RATES AMONG CAMBRIDGE UNDERGRADUATES, AND THE FREQUENCY DISTRIBUTION OF SUICIDES.—Table I shows the population at risk, the number of suicides, and the suicide rates for male Cambridge undergraduates for four periods going back to October, 1923. These rates are all based on small numbers of cases and to draw any conclusions about them it is necessary to know what fluctuations are likely to be due to chance.

TABLE I
SUICIDE RATES FOR MALE CAMBRIDGE UNDERGRADUATES, 1923–58
95 PER CENT. CONFIDENCE INTERVALS FOR THESE RATES ARE ALSO SHOWN

| Period | Average Undergraduate Population | No. of Suicides | Suicide Rate (per 100,000 per year) | 95 per cent. Confidence Interval |
|---|---|---|---|---|
| Oct., 1923.–Sept., 1928 | 4,455 | 1 | 4·5 | 0·1 to 25·0 |
| Oct., 1928.–Sept., 1938 | 4,814 | 10 | 20·7 | 10·0 to 38·2 |
| Oct., 1938.–Sept., 1948 | 3,693 | 12 | 32·5 | 16·8 to 56·8 |
| Oct., 1948.–Sept., 1958 | 5,950 | 13 | 21·8 | 11·6 to 37·4 |
| Oct., 1923.–Sept., 1958 | 4,767 | 36 | 21·6 | 15·1 to 29·9 |

To be able to predict this, the pattern of the variations in the rates needs to be studied. This can be done by considering the variations in the numbers of suicides per year. If cases of suicide were independent events, we should expect a binomial distribution, or, since the probability of a student committing suicide is very small, a Poisson distribution. The assumption of independence implies that

the occurrence of a suicide does not greatly encourage, or discourage, suicide in similarly depressed students. This does not seem an unreasonable assumption, as any effect of this kind is likely to be very temporary. Further, the assumption of independence has been found to work well when considering mortality of all forms, in spite of the fact that some of it may be due to infectious epidemics (Carpenter and Cochrane, 1956).

Table II therefore compares the observed and expected distributions of the number of suicides per year.

TABLE II

OBSERVED DISTRIBUTION OF THE NUMBER OF SUICIDES PER YEAR AMONG MALE CAMBRIDGE UNDERGRADUATES, 1923–58, AND EXPECTED DISTRIBUTION IF SUICIDES WERE INDEPENDENT EVENTS

| No. of Suicides per Year | No. of Years | Expected Frequency |
|---|---|---|
| 0 | 15 | 13·51 |
| 1 | 9 | 11·65 |
| 2 | 8 | 6·39 |
| 3 | 2 | 2·48 |
| 4 | — | 0·74 |
| 5 | 1 | 0·18 |
| 6+ | — | 0·05 |
| Total .. .. | 35 | 35·00 |

The expected distribution was calculated as follows:

In each of four periods (October, 1923, to September, 1928; October, 1928, to September, 1938; October, 1938, to September, 1948; October, 1948, to September, 1958) the number of suicides per year were assumed to follow a Poisson distribution, the mean being given by the mean suicide rate for the period. The four means are shown in Table I. The expected frequency shown in Table II is derived from the sum of the four Poisson distributions.

It can be seen that the observed distribution follows the expected distribution very closely. The number of years are too few to apply any but a very crude test of agreement, but the departure from expectation could scarcely be less. It is therefore concluded that, at least within these periods, suicides may be regarded as independent events.

Hence, from Tables of the Poisson distribution (Pearson and Hartley, 1956), it is immediately possible to set confidence intervals to the suicide rates given in Table I, and these are shown in the last two columns of Table I.

A confidence interval may be briefly described as follows:

Suppose conditions relative to suicide in the University remained unchanged, it would then be possible to observe a very large number of students with the same risk of committing suicide as that run by any particular group under consideration. The rate that would be observed in the very large group can be regarded as the "true suicide rate". The confidence interval given for any observed suicide rate is an interval in which the corresponding true rate will almost certainly lie.

When dealing with very small numbers of cases, as in the present study, more attention should be paid to the confidence intervals and tests of statistical significance than to the particular rates that happen to be observed.

From the assumption of suicides being independent events, we may proceed to apply a $\chi^2$ test to the data in Table I to determine whether there is any evidence that the suicide rate has changed during the last 35 years. $\chi^2$ on three degrees of freedom is 5·07, giving $0{\cdot}2 > P > 0{\cdot}1$. There is, therefore, little evidence to suggest any real change in the rates, in spite of the fact that we only know of one suicide in the period October, 1923, to September, 1928.

Since there is little evidence of any change in the rates during the 35-year period, we may set a confidence interval to the mean rate for the whole period. If the incidence of suicide in the University remains unchanged, the suicide rate will, over a very long period, almost certainly lie between 15·1 and 29·9 per 100,000 students at risk per year. The chance of a repetition of the year in which five suicides occurred may also be calculated. If the suicide rate stays at its present level and the University at its present size (*i.e.* 7,300 undergraduates), five or more suicides in one year will, in the long run, probably not occur more often than once in 14 years and not less often than once in 180 years, and most likely about once in 40 years.

COMPARISON OF THE SUICIDE RATES AT VARIOUS UNIVERSITIES.—Table III shows the suicide rates that are being experienced by male students at Cambridge, Oxford, University College (London), and seven other British universities. The Table also shows confidence intervals for these rates. A $\chi^2$ test shows that there are real differences between the experience recorded at the different universities, the rate at the seven British universities taken together being significantly lower than the rates at Cambridge

TABLE III

POST-WAR SUICIDE RATES FOR MALE STUDENTS AT VARIOUS UNIVERSITIES

95 per cent. Confidence Intervals are shown for these Rates and also which Rates are Significantly Different

| Students | Duration of Observation (yrs) | Average Population | No. of Suicides | Suicide Rate (per 100,000 per year) | 95 per cent. Confidence Interval | Significance of Differences* |
|---|---|---|---|---|---|---|
| Cambridge Undergraduates | 10 | 5,950 | 13 | 21·8 | 11·6 to 37·4 | } |
| Oxford Undergraduates | 10 | 5,250 | 16 | 30·5 | 17·4 to 49·5 | } |
| Students of University College, London | 7 | 2,500 | 4 | 22·9 | 6·2 to 58·5 | } |
| Students at Seven Other British Universities | 8·5 | 15,000 | 10 | 7·8 | 3·8 to 14·4 | } |

* Differences between rates which are bracketed together have a chance greater than 0·05 of occurring, *i.e.* these differences are not statistically significant.

or Oxford. The data for University College, London, are too small to indicate whether the true rate is higher than the rate at the seven other British universities or not, though the data so far suggest an experience comparable with that at Oxford and Cambridge.

COMPARISON WITH THE NATIONAL RATES: AGE.—Table IV shows the suicide rates for males in England and Wales in three age groups for the periods 1921–23, 1930–32, and 1949–53. At each period there is a definite rise in the suicide rate with age, a feature which is regularly observed.

TABLE IV

MALE SUICIDE RATES PER 100,000 PER YEAR IN ENGLAND AND WALES FOR THREE AGE GROUPS AND FOR THREE PERIODS

| Period | Age Group (yrs) | | |
|---|---|---|---|
| | 16– | 20– | 25–34 |
| 1921–23 | 3·4 | 7·2 | 9·9 |
| 1930–32 | 3·8 | 9·8 | 13·3 |
| 1949–53 | 3·5 | 6·0 | 8·0 |

In the academic year 1951–52, 77 per cent. of the undergraduates came for medical examination during their first year. Over 90 per cent. of the men examined were in the age group 18 to 22, which implies that the majority of the university were in the age group 18 to 24, as most academic courses last for 3 years. The age range of the women examined was much narrower, 90 per cent. of them being aged 18 or 19. Most of the women undergraduates in the university therefore probably belong to the age group 18 to 21.

Before the war when there was no national service, the age distribution of the men was probably similar to that of the women in 1951. It remained much the same during the war, the majority of students having come from school, but after the war the age range widened considerably owing to the large intake of men who had been in the forces during the war. The age distribution of the women students has probably altered little.

The national death rates are given for groups under 20, 20 to 24, 25 to 34, etc. The age group most comparable to that of university students is obviously the group 20 to 24. On account of the rise of the suicide rate with age, the national rate for this group will generally be a little too high. This will apply particularly to comparisons of pre-war figures for men and to rates for women. For the immediate post-war period rates slightly higher than those experienced by men aged 20 to 24 might be expected in the university, but the excess would be small.

It is concluded that the age group 20 to 24 is the appropriate group when comparing university suicide rates with national experience. To use the age group 15 to 24 for comparison, as Parnell (1951) has done, will probably tend to give an unfavourable picture of the mortality experienced at university.

CHANGES IN NATIONAL SUICIDE RATES SINCE 1921 AND THE EFFECTS OF SOCIAL CLASS.—The trends in national suicide rates for men aged 20–24 are shown in Table V (opposite), which gives the average rates in 5-year periods since 1921. The suicide rate rises to a peak in the period 1931–35 and then falls again, so that it is now just below what it was in 1921–25.

Social class also has an important effect on suicide rates, but national rates by age, sex, and social class can only be calculated for the periods 1921–23, 1930–31, and 1949–53. Table V shows clearly that these three periods will adequately represent the changes there have been in the suicide rates for the age group 20–24 since 1921.

TABLE V

SUICIDE RATES FOR MALES AND FEMALES AGED 20–24, BETWEEN 1921 AND 1955 IN FIVE-YEAR PERIODS, IN ENGLAND AND WALES
(Civilians only)

| 5-year Periods | Rate per 100,000 per Year | |
|---|---|---|
| | Male | Female |
| 1921–25 | 7·1 | 4·0 |
| 1926–30 | 8·4 | 4·5 |
| 1931–35 | 9·6 | 4·9 |
| 1936–40 | 8·9 | 3·8 |
| 1941–45 | 7·2 | 2·2 |
| 1946–50 | 6·1 | 2·5 |
| 1950–55 | 5·8 | 1·9 |

Table VI accordingly shows the population, the suicide rates, and confidence intervals for the rates, by social class in the three periods 1921–23, 1930–32, and 1949–53 for males aged 20–24. In these classifications students are included with all other persons not gainfully occupied. This group does not, however, contain those who are temporarily out of work, who are classified either by their last occupation or under a special code.

The numbers of students are given or may be determined from the Census Reports, but the numbers of student suicides are not generally available. The Registrar General, in a private communication, provided this information for the period 1949–53 and the rates for students are accordingly shown. The suicide rates for all other persons not gainfully occupied, and for all persons not gainfully occupied for 1949–53 are also shown in Table VI. It can be seen that students form so large a percentage of all persons not gainfully occupied in this age group that the suicide rate for the group as a whole is only a little higher than for students alone. As students comprise more than 56 per cent. of all persons not gainfully occupied in the two previous periods it is thought that the suicide rates for all persons not gainfully occupied provide some guide as to the student suicide rates in these periods.

COMPARISON OF SUICIDE RATES IN VARIOUS GROUPS.—The rates and confidence intervals set out in Table VI are illustrated in the Figure (overleaf). Some guide to the statistical significance of differences between groups may be obtained as follows:

If the rate for one group lies within the confidence interval for another the rates are not significantly different. If the confidence intervals for two rates do not overlap the difference is highly significant. Intermediate cases may or may not be significantly different.

Table VI and the Figure show that the rates for all males aged 20–24 in the three periods reflect the changes in the rates since 1921. The rise of the suicide rate in the 1930s and the subsequent fall to about the same rate as in 1921 is clearly shown in Social Classes II, III, and IV, and to a lesser extent in Social Classes I and V. The rates for all students do not however show this pattern. Presumably persons not gainfully occupied were not much affected by the social conditions which caused the rise in the suicide rates in the 1930s.

In consequence, the estimated rates for all students are significantly above the rates for all males in 1921–23. In 1930–32 the difference is not significant, and the observed suicide rate in Social Class II is higher than among all persons not gainfully occupied. In 1949–53 the suicide rates for all

TABLE VI

MALE SUICIDE RATES PER 100,000 PER YEAR IN ENGLAND AND WALES FOR THE AGE GROUP 20 to 24, BY SOCIAL CLASS, IN 1921, 1931, AND 1951
95 per cent. Confidence Intervals are also shown

| Year | | | 1921 | | | 1931 | | | 1951 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Population (1921)* | Suicide Rate (1921–1923) | 95 per cent. Confidence Interval | Population (1931) | Suicide Rate (1930–1932) | 95 per cent. Confidence Interval | Population (1951) | Suicide Rate (1949–1953) | 95 per cent. Confidence Interval |
| Social Class | I | | 23,186 | 4·3 | 0·9 to 12·6 | 21,778 | 7·7 | 2·5 to 17·9 | 35,618 | 6·7 | 3·5 to 11·8 |
| | II | | 200,794 | 10·1 | 7·7 to 13·0 | 104,201 | 14·7 | 10·8 to 19·6 | 107,320 | 6·1 | 4·2 to 8·6 |
| | III | | 614,342 | 6·3 | 5·2 to 7·6 | 933,168 | 8·4 | 7·3 to 9·5 | 836,118 | 4·8 | 4·2 to 5·5 |
| | IV | | 327,927 | 6·1 | 4·7 to 7·9 | 335,223 | 11·2 | 9·3 to 13·5 | 218,348 | 5·5 | 4·2 to 7·1 |
| | V | | 174,442 | 6·1 | 4·2 to 8·6 | 257,046 | 10·2 | 8·1 to 12·8 | 163,824 | 7·7 | 5·9 to 9·8 |
| | Not gainfully Occupied | Students | 19,415 | 14·4 | 8·1 to 23·8 | 27,010† | 14·0 | 8·5 to 21·6 | 53,659 | 15·7→ ←17·0 | 11·3 to 21·2 |
| | | Others | 15,211* | | | 20,715 | | | 12,341 | 22·7→ | 12·4 to 38·1 |
| All Males | | | 1,375,317 | 7·0 | 6·2 to 7·8 | 1,699,141 | 9·8 | 8·9 to 10·6 | 1,427,228 | 6·0 | 5·4 to 6·5 |

* Excludes active and retired members of the armed forces. ("Retired" means those who had retired from service who had not subsequently taken up civilian employment.)

† Estimated.

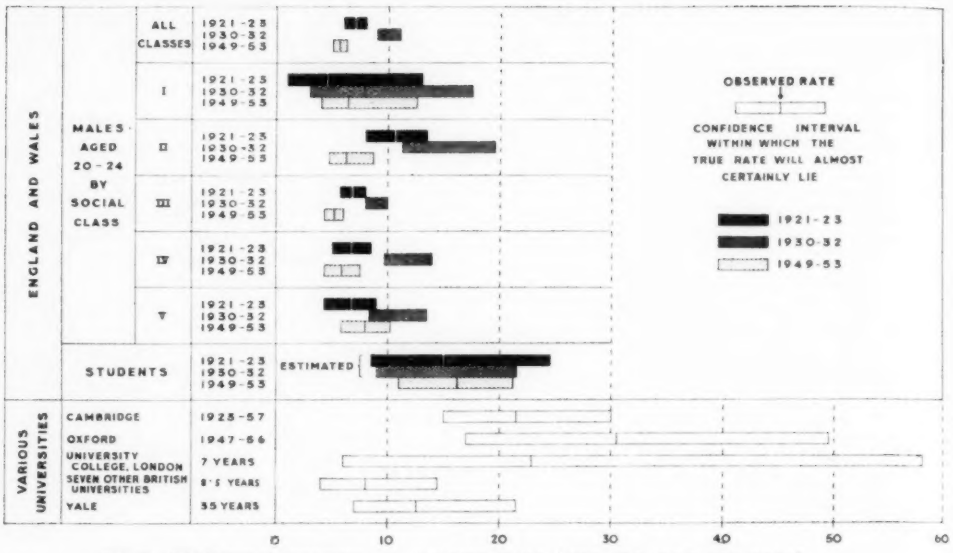


FIGURE.—Suicide rates of young males

students aged 20–24 were again significantly above the rates for all males, and were also significantly higher than the rates in any social class.

Thus, in 1949–53, students aged 20–24 formed a group at special risk of committing suicide. The observed suicide rate for this group was 261 per cent. of that of all males of the same age. Estimates suggest there has been little change in the suicide rates among students since 1920.

The Figure also shows the suicide rates for various universities. The average rate for Cambridge students during the last 35 years is above the rates for all students, but the difference is not statistically significant. Nor is the difference significant if the experience in Cambridge in the last 10 years is compared to that among all students aged 20–24 in 1949–1953. The suicide rates among Oxford students in the period 1948–1957 is significantly above that of all students ($0{\cdot}05 > P > 0{\cdot}01$). The rates for University College, London, are very uncertain. The rate for the seven other British universities is below the rates for all students in England and Wales aged 20–24, but the difference is not statistically significant.

The suicide rate at Yale University over 35 years has been 13 per 100,000 per year (Parrish, 1957). The confidence interval for this rate is 7·3 to 21·5. These figures are shown for comparison in the Figure. The rate at Yale is similar to that of all students aged 20–24 in England and Wales. It is not significantly below that observed at Cambridge, but is statistically significantly less than that reported at Oxford ($0{\cdot}05 > P > 0{\cdot}01$).

## Factors Affecting Suicide Rates

*Colour.*—Three of the suicides that occurred in the last 10 years among Cambridge students were those of coloured students from overseas. Owing to the small population at risk this suggests a very high suicide rate among overseas students at Cambridge, but the number of cases is so small that the difference in suicide rates between them and the rest of the students is not significant. We do not know of any such overseas undergraduates at Cambridge committing suicide before 1948. If these three cases at Cambridge had been omitted from the 1948–58 data for Cambridge in the foregoing analysis, the conclusions would not have been altered in any way.

*Age.*—Table VII shows the age distribution of cases of suicide among male undergraduates for four periods. The cases form a fair sample of the undergraduate population, and the tendency for

undergraduates to be older since the war can be seen. Three cases however, seem somewhat older than the rest. These were all reading ordinary undergraduate courses leading to a B.A. degree, and it cannot be regarded as surprising that some cases of suicide should occur among the older undergraduates. What Table VII does show clearly is that the few older men at the University do not explain the high rates of suicide at Cambridge.

TABLE VII

AGE DISTRIBUTION OF SUICIDES AMONG MALE CAMBRIDGE UNDERGRADUATES FOR FOUR PERIODS

| Period | Age (yrs) | | | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | |
| Oct., 1923, to Sept., 1928 | — | — | 1 | — | — | — | — | — | — | 1 |
| Oct., 1928, to Sept., 1938 | — | 5 | 2 | 1 | 1 | — | — | — | 1 | 10 |
| Oct., 1938, to Sept., 1948 | 3 | 4 | 1 | 2 | 1 | — | — | 1 | — | 12 |
| Oct., 1948, to Sept., 1958 | 1 | 2 | 6 | 3 | — | — | 1 | — | — | 13 |
| Total .. | 4 | 11 | 10 | 6 | 2 | — | 1 | 1 | 1 | 36 |

*Time of Year.*—Term-time* at Cambridge only lasts for 24 weeks of the year. The percentages of suicides occurring in term-time and at other times in the year are shown in Table VIII. The contrast between term-time and vacation is striking. The incidence of suicide is, however, known to fluctuate with the time of year. The fluctuations to be expected were estimated as follows:

The best control material is provided by the Registrar General's Weekly Returns (1923 to 1958), which show the number of suicides that have occurred in London each week by age and sex. The number occurring among males aged 20–24 were abstracted and tabulated by terms and vacations. The 8 weeks most closely corresponding to each term between October, 1923, and October, 1958, had previously been determined from the Ordinances of the University (1923 to 1958).

The results for London shown in Table VIII do not suggest that there has been any real difference between the suicide rate in term-time and vacation when the three terms and the three vacations are taken together. This applies to the periods both before and after October, 1948.

We, therefore, conclude from Table VIII that in the last 10 years the suicide rate in term-time among male Cambridge undergraduates has been rather more than double that shown in Table I, *i.e.* a rate of 47·3 per 100,000 per year. The confidence interval for this rate is 25·1 to 81·0 per 100,000 per year. For the whole period the term-time suicide rate has been 39·0 per 100,000 per year, and the confidence interval for the rate is 26·3 to 55·6 per 100,000 per year.

The association shown in Table VIII of the cases of suicide among the Cambridge undergraduates with term-time is highly significant ($0{\cdot}01 > P$). This applies both to the whole period and to the last 10 years. There are two possible explanations: the first is that the suicide rate is higher in term-time because of the stress of life at the University; the other is that the association is caused by the oversight of cases that have occurred in the vacation.

The association of suicide with term-time over the last 10 years would not have been significant had six cases occurred in the vacations without coming to the notice of the University Health Service. This, in turn, would imply that the suicide rate among Cambridge undergraduates has been at least 31·9

* *Term-time* in this paper describes the period when the undergraduates are in residence, and corresponds to what in Cambridge is known as 'full term'.
*Vacation* in this paper describes any time other than term-time.

TABLE VIII

PROPORTION OF SUICIDES EXPECTED TO OCCUR AND OCCURRING IN TERM-TIME AND AT OTHER TIMES AMONG MALE CAMBRIDGE UNDERGRADUATES AND AMONG MALES AGED 20–24 IN LONDON FOR THE PERIOD OCTOBER, 1923, TO SEPTEMBER, 1958

| Group | | Percentage Suicides Occurring | | | No. of Cases |
|---|---|---|---|---|---|
| | | Term-time† | Vacation† | Total | |
| Cambridge Undergraduates | Oct., 1923, to Sept., 1948 .. | 73·9 | 26·1 | 100 | 23 |
| | Oct., 1948, to Sept., 1958 .. | 100 | — | 100 | 13 |
| | Whole Period .. .. .. | 83·3 | 16·7 | 100 | 36 |
| London Males aged 20–24 yrs | Oct., 1923, to Sept., 1948 .. | 48·1 | 51·9 | 100 | 673 |
| | Oct., 1948, to Sept., 1958 .. | 45·1 | 54·9 | 100 | 206 |
| | Whole Period .. .. .. | 47·4 | 52·6 | 100 | 879 |
| Expected Suicides* .. .. .. .. .. .. .. | | 46·2 | 53·8 | 100 | — |

* The expected percentage assumes equal suicide rates in term-time and at other times.
† See footnote on this page, col. 1.

per 100,000 per year over the last 10 years. Applying a similar argument to the whole period of 35 years, rejection of the hypothesis of suicide being associated with term-time implies that the suicide rate for the whole period must have been at least 30·0 per 100,000 per year. These rates are similar to the rate for Oxford University shown in Table III.

Probably both hypotheses are true, namely, that the occurrence of suicide is to some extent associated with term-time, and also that some unknown cases of suicide have occurred during the vacations so that the suicide rate has been higher than reported.

It was also thought that there might be a tendency for suicides to occur in the Easter Term when most of the examinations are held. The observed percentage of cases occurring in each term is compared with the percentage that occurred in London in Table IX.

TABLE IX

PERCENTAGE OF SUICIDES AMONG MALE UNDERGRADUATES IN EACH FULL TERM AT CAMBRIDGE BETWEEN OCTOBER, 1923, AND SEPTEMBER, 1958, COMPARED WITH THOSE IN COMPARABLE WEEKS AMONG MALES IN LONDON AGED 20–24 YRS

| Group | Percentage Suicides | | | | Total Suicides |
|---|---|---|---|---|---|
| | Michaelmas | Lent | Easter | Total | |
| Cambridge Undergraduates .. | 26·7 | 30·0 | 43·3 | 100 | 30 |
| London Males aged 20–24 yrs .. | 27·3 | 38·1 | 34·5 | 100 | 417 |

The percentage that occurred in London varies significantly between the terms, so that the number of suicides would be expected to rise in the Lent and Easter terms, and the incidence would be expected to be maximum in the Lent term. The observed distribution of suicides at Cambridge shows some departure from this pattern. Thirteen of the thirty deaths that occurred in term-time occurred in the summer term, while only 10·4 would be expected from the London data, but the departure is not statistically significant. The departure was more marked in the period October, 1948, to September, 1958. In this period eight of the thirteen suicides occurred in the Easter term, which suggests that there may have been a change in the time of year at which cases tend to occur. The numbers are, however, too small for any definite conclusions to be drawn.

*Year of Residence.*—Table X shows the year of residence of the cases of suicide occurring in term-time. Suicides occurring in the vacation have been excluded because of the difficulty of defining the year of the student, and also because the third year does not normally include a long vacation. In the first nine terms of residence, 29 suicides occurred. Equal numbers of these would be expected in each year, for although a few men go down before the third year the number is insufficient to make an appreciable difference to the population at risk. A $\chi^2$ test shows that there are significantly fewer cases of suicide among third year students than expected. Only two of the cases were in their ninth term, and both occurred before October, 1948. The tendency in the period October, 1948, to September, 1958 seems to be for suicide to occur in the summer term of the second year, for six of the thirteen cases in this period occurred then. Thus, while there is some suggestion that in the 10 years since 1948 student suicides may be associated with second year examinations, there is nothing to suggest a general association with final examinations.

TABLE X

YEAR OF RESIDENCE OF SUICIDES AMONG MALE CAMBRIDGE UNDERGRADUATES OCCURRING IN TERM-TIME

| Year of Residence | First | Second | Third | Fourth | Total |
|---|---|---|---|---|---|
| No. of Suicides . | 11 | 15 | 3 | 1 | 30 |

SUICIDE RATES FOR WOMEN STUDENTS.—During the 10 years October, 1948, to September, 1958, the average number of women undergraduates in Cambridge has been 630, and during this time there has been one suicide. This suggests that the suicide rate is comparable to that of male students, but the data are so small that the confidence interval for the true rate ranges from below 1 to over 80 per 100,000 per year, and clearly no conclusions can be drawn. One other case of suicide occurred among women students at the universities for which data have been published. In all, the population at risk is equivalent to observing 63,800 women students for one year. Two suicides occurred, giving an observed rate of 3·1 per 100,000 per year, and a confidence interval for the true rate of 0·4 to 11·3 per 100,000 per year.

The national suicide rates for women aged 20–24 have, since 1920, followed a pattern almost identical to that of the males as is shown in Table V, except that the rates for women have been about half the male rates. Table XI (opposite) shows the suicide rates for single women by social class for the period 1949–53. The pattern is similar to that of males of comparable age, but the numbers of cases are very small and the rates are therefore somewhat erratic.

The Registrar General, in the private communication already referred to, informed us that there were

TABLE XI

SUICIDE RATES PER 100,000 PER YEAR FOR SINGLE WOMEN AGED 20–24, BY SOCIAL CLASS, ENGLAND AND WALES, 1949–53

| Women in England and Wales | | Suicide Rate |
|---|---|---|
| Social Class .. | I | 10·0 |
| | II | 2·6 |
| | III | 1·4 |
| | IV | 5·6 |
| | V | 1·1 |
| | Not Gainfully Occupied .. | 4·2 |
| All Single Women .. .. | | 2·1 |
| All Women Students (aged 20–64) | | 4·4 |

seven cases of suicide among whole-time women students in England and Wales in the years 1949–53. The ages were not specified beyond indicating that they were over 20 and under 65. Even in the oldest age groups there are a few women who are whole-time students. At the 1951 census there were 31,999 women students over the age of 20 and under the age of 65, giving a suicide rate for the group of 4·4 per 100,000 per year. The 95 per cent. confidence interval for this rate is 1·8 to 9·1. However, as 81 per cent. of these women students were aged 20–24, and 94 per cent. of them were single, their suicide rate may be compared with the rates for single women aged 20–24 shown in Table XI. The suicide rate for the women students is above the rate for all women aged 20 to 24, but the difference is not statistically significant. The only statistically significant difference is between the rate for women students aged 20–64 and women aged 20–24 in Social Class III ($0{\cdot}05 > P > 0{\cdot}01$). The rate of 1·1 for Social Class V is based on only two suicides.

The effect of including 19 per cent. of students over 25 would be to increase the suicide rate slightly. The suicide rate for all single women aged 24–34 in 1949–53 was 5·6 per 100,000 per year. On the other hand, suicide rates for married women are slightly lower than for single women, the rates in 1949–53 being 1·8 for all married women aged 20–24 and 3·3 for the age group 25–34.

Thus, although the national figures indicate that women students may have a slightly increased suicide rate, the difference is not statistically significant. Death rates from suicide in women are in any case substantially below the rates for men.

MORTALITY FROM ALL CAUSES.—Table XII shows the England and Wales death rates from all causes for male students in three age groups. The death rates for all other males in these age groups are shown by social class. For completeness, the death rates for students at Oxford and Cambridge are also shown, although the rates for Cambridge are probably too low.

TABLE XII

DEATH RATES PER 100,000 PER YEAR IN THREE AGE GROUPS FOR ALL MALE STUDENTS IN ENGLAND AND WALES AND FOR ALL MALES BY SOCIAL CLASS, WITH THE RATES FOR OXFORD AND CAMBRIDGE STUDENTS AT ALL AGES

| England and Wales | | | Age Group (yrs) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 16–19 | | | 20–24 | | | 25–34 | | |
| | | | Total Deaths (1949–53) | Population (1951) | Mean Death Rate (per 100,000 per yr) | Total Deaths (1949–53) | Population (1951) | Mean Death Rate (per 100,000 per yr) | Total Deaths (1949–53) | Population (1951) | Mean Death Rate (per 100,000 per yr) |
| All Students .. .. .. .. | | | 243 | 106,543 | 46 | 311 | 53,659 | 116 | 136 | 22,992 | 118 |
| All Males | Social Class | I | 91 | 13,673 | 133 | 370 | 35,618 | 208 | 885 | 109,048 | 162 |
| | | II | 200 | 32,885 | 122 | 595 | 107,320 | 111 | 2,174 | 382,618 | 114 |
| | | III | 2,736 | 651,843 | 84 | 5,118 | 836,118 | 122 | 13,164 | 1,780,598 | 148 |
| | | IV | 812 | 156,204 | 104 | 1,471 | 218,348 | 135 | 3,731 | 479,834 | 156 |
| | | V | 537 | 85,036 | 126 | 1,277 | 163,824 | 156 | 3,619 | 338,975 | 214 |
| | | Not Gainfully Occupied (excluding students) .. | 782 | 6,768 | 2,311 | 725 | 12,341 | 1,175 | 1,309 | 25,656 | 1,020 |
| | Total .. .. .. .. | | 5,401 | 1,052,952 | 103 | 9,867 | 1,427,228 | 138 | 25,018 | 3,139,721 | 159 |

| Undergraduates (All Ages) | Total Deaths | Mean Population at Risk | Mean Death Rate |
|---|---|---|---|
| Cambridge (1948–57)* .. .. | 37 | 5,950 | 62 |
| Oxford (1947–49) .. .. .. | 33 | 5,048 | 218 |

* Academic years

Table XII shows that students in England and Wales are a favoured class so far as mortality is concerned, their rates being lower than the rates for males of comparable age in any of the social classes. The death rates for Cambridge undergraduates are lower than the rates for all students aged 20–24. In contrast, the death rates among Oxford undergraduates in 1947–49 are significantly above the rates for all students aged 20–24 ($0{\cdot}01 > P > 0{\cdot}001$), and are comparable to the rates for males in Social Class I.

Table XIII shows the distribution of deaths according to cause for the groups shown in Table XII. Three groups of causes are shown: accident, suicide, and disease. Accidents, mostly motor accidents, cause a very high proportion of all deaths in Social Class I. As social class declines the proportion of deaths due to accident declines and the proportion due to disease increases. The very high death rates among those never gainfully occupied shown in Table XII are to be expected. This group will comprise all persons in institutions and all invalids, and, as shown in Table XIII, the majority of deaths in this group are due to disease.

The distribution of deaths among all students is noticeably different. This group has a favourable mortality experience from accident and disease and an unfavourable experience of suicide. Hence, the substantial increase in the proportion of deaths due to suicide. The proportion due to suicide is still further increased among Oxford undergraduates, the increase being statistically significant. The distribution of deaths among Cambridge undergraduates again shows a higher percentage of suicides, the difference between the two universities being statistically significant. However, little weight can be put on the figure of 35 per cent. for the proportion of deaths among Cambridge undergraduates due to suicide. It is probably inflated by under-enumeration of deaths due to accident and disease. It serves, if anything, to show that the under-enumeration relates to causes other than suicide.

ALL FORMS OF MORTALITY AMONG WOMEN STUDENTS.—During the last 10 years five deaths have occurred among women undergraduates at Cambridge. Parnell (1951) records two deaths among women at Oxford in the period 1947–49. These seven deaths give a death rate of 73 per 100,000 per year.

Table XIV (opposite) shows the death rates for single women aged 20 to 24 by social class, and also the rate for all women students aged 20–64. It can be seen that the death rates for women at Oxford and Cambridge, and for all women students, are lower than the rates for single women in Social Classes I and III, and higher than those for single women in Social Class II.

As with males there is a tendency for the proportion of deaths due to accident to decrease as

TABLE XIII

PERCENTAGE OF DEATHS DUE TO VARIOUS CAUSES IN THREE AGE GROUPS FOR ALL MALE STUDENTS IN ENGLAND AND WALES AND FOR ALL MALES BY SOCIAL CLASS, WITH THE RATES FOR OXFORD AND CAMBRIDGE UNDERGRADUATES AT ALL AGES

| England and Wales | | | Age Group | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 16–19 | | | | 20–24 | | | | 25–34 | | | |
| Cause of Death | | | Accident | Suicide | All Other Causes | Total | Accident | Suicide | All Other Causes | Total | Accident | Suicide | All Other Causes | Total |
| All Students | | | 31·7 | 7·4 | 60·9 | 100 | 37·0 | 13·5 | 49·5 | 100 | 19·9 | 15·4 | 64·7 | 100 |
| All Males | Social Class | I | 72·5 | 5·5 | 22·0 | 100 | 72·7 | 3·2 | 24·1 | 100 | 44·6 | 7·8 | 47·6 | 100 |
| | | II | 42·5 | 3·0 | 54·5 | 100 | 39·8 | 5·5 | 54·6 | 100 | 19·5 | 6·9 | 73·7 | 100 |
| | | III | 42·3 | 4·0 | 53·8 | 100 | 41·8 | 3·9 | 54·3 | 100 | 22·9 | 4·4 | 72·7 | 100 |
| | | IV | 45·2 | 3·2 | 51·6 | 100 | 38·7 | 4·1 | 57·2 | 100 | 23·2 | 4·9 | 71·9 | 100 |
| | | V | 36·0 | 3·2 | 60·9 | 100 | 27·9 | 4·9 | 67·1 | 100 | 20·2 | 6·5 | 73·3 | 100 |
| | | Not Gainfully Occupied (excluding students) | 9·7 | 0·5 | 89·8 | 100 | 5·2 | 1·9 | 92·8 | 100 | 6·0 | 1·8 | 92·2 | 100 |
| | Total | | 37·4 | 3·4 | 59·2 | 100 | 37·7 | 4·3 | 58·0 | 100 | 22·1 | 5·0 | 72·8 | 100 |

| Undergraduates (All Ages) | Cause of Death | | | |
|---|---|---|---|---|
| | Accident | Suicide | All Other Causes | Total |
| Cambridge | 37·8 | 35·1 | 27·0 | 100 |
| Oxford | 48·5 | 27·3 | 24·2 | 100 |

TABLE XIV

DEATH RATES PER 100,000 PER YEAR FOR SINGLE WOMEN AGED 20–24, BY SOCIAL CLASS, AND FOR ALL WOMEN STUDENTS AGED 20–64, ENGLAND AND WALES, 1949–53

| England and Wales | | | Death Rate (per 100,000 per year) |
|---|---|---|---|
| All Single Women | Social Class | I | 85 |
| | | II | 46 |
| | | III | 83 |
| | | IV | 117 |
| | | V | 124 |
| | | Not Gainfully Occupied | 329 |
| | Total .. .. .. .. | | 112 |
| All Women Students aged 20–64 .. .. | | | 66 |

social class decreases, but the change is not nearly so dramatic, the percentages ranging only from 16 to 5. The distribution of the 106 deaths among all women students, when divided into the three main groups (accident, suicide, and disease) is almost identical with that of single women aged 20–24 in Social Class II.

Thus the data relating to women students all suggest that their mortality experience is comparable with that of a group largely selected from the higher social classes.

## SUMMARY

The methods of collecting data relating to cases of suicide among Cambridge undergraduates during the last 35 years, and to deaths from all causes during the last 10 years are described. Misclassification is unlikely, but under-enumeration could easily have occurred, especially of deaths due to disease. This is borne out by the distribution of deaths by cause.

A study of the frequency distribution of the numbers of deaths per year shows the assumption, that cases of suicide are independent events, to be reasonable. The use of standard statistical methods for handling Poisson and binomial variables is therefore justified.

There is no evidence that the suicide rates among male Cambridge undergraduates have changed during the last 35 years. If the University remains at its present size and the present suicide rates continue, five or more cases of suicide in one year are, in the long run, to be expected about once in 40 years, and not more than once in 14 years. One such year has already occurred.

Suicide rates for male undergraduates seem slightly lower at Cambridge than at Oxford, but they are significantly higher than the rates for men at seven other British universities.

Age has an important effect on suicide rates and the national rates for the 20–24 age group provide the best standard by which to compare the rates experienced in the universities. In this age group all social classes experienced a rise in the suicide rate in the 1930s, which was followed by a decline to about the 1920 level. National rates for students do not seem to show this pattern, but to have remained constant.

In the period 1949 to 1953, students in England and Wales experienced suicide rates significantly above the rates for males in any of the five social classes. The suicide rate in Cambridge during the last 35 years has been higher, but not significantly higher, than the national rate for students aged 20–24. The rate experienced in Oxford in the last 10 years is significantly higher than the national rate.

Three cases of suicide among coloured students from overseas studying at Cambridge have tended to inflate the suicide rate for the last 10 years, but there are not enough data to show whether coloured students are at any special risk, nor are the foregoing conclusions affected if coloured students are excluded.

The age distribution of students committing suicide corresponds to that of all students in the University. In the last 10 years the suicide rate in term-time has been about eight times the rate among all males. It seems probable that suicide is more likely to occur in term-time than in the vacation. There is little evidence to suggest that the number of suicides occurring during the term when most of the examinations are held is greater than is to be expected, although in the last 10 years 46 per cent. of the suicides have occurred in the Easter term among second-year students, which may represent a real change in the pattern of suicides. The figures for the whole 35 years show that suicide is more likely to occur during the first 2 years of residence than in the third, and there is nothing to suggest an association between the occurrence of suicide and the examinations held in the third year.

Suicide rates among single women aged 20–24 follow very much the same pattern as that described for men, but are lower. There is a slight suggestion that the rates may be higher for women students than for all single women, but the increase is not statistically significant.

Death rates from all causes are reviewed. The death rate among male students as a class is low, and that from all causes for Cambridge students may be lower than that experienced by all students. The death rate reported by Parnell (1951) for Oxford seems remarkably high.

As the suicide rates of male students tend to be above the rates for other groups, and their death rates from other causes are low, suicide accounts for a very much higher proportion of male student deaths than of deaths in other groups of the population.

Women students seem to have death rates typical of the social classes from which they are drawn.

I am much indebted to Prof. A. Leslie Banks for encouraging this study, to Sir Alan Rook who made it possible by giving me full access to the University Health Service Records and also for many helpful suggestions, to the Registrar General for supplying data on student mortality, to the University Registry for access to their records, and to Mr. R. Dent for making the search for those records and for other assistance.

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# VARIABILITY IN ANSWERS TO A QUESTIONNAIRE ON RESPIRATORY SYMPTOMS

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Chronic bronchitis can be recognized, in its early stages, only from the patient's account of his symptoms. During the last few years the prevalence of respiratory symptoms has been surveyed in many populations in the United Kingdom. A more or less uniform questionnaire has been developed by certain workers in consultation; but until recently there has been no general agreement on its content or layout. The questionnaire is completed by one observer at one interview with each subject.

Cochrane, Chapman, and Oldham (1951) showed that observers reported widely different prevalence rates of respiratory symptoms in separate random samples of a population of miners. Schilling, Hughes, and Dingwall-Fordyce (1955) also found systematic differences in the extent to which two observers reported respiratory symptoms at interviews with the same group of cotton workers. In the surveys reported by Higgins (1959), the same observer conducted all the interviews and observer variability was thus avoided. If, however, the epidemiology of chronic bronchitis is to be more widely studied, the technique of symptomatic inquiry must be standardized so that the results of different investigators may be compared. Our purpose in this survey was to compare several observers in the use of a detailed standardized questionnaire. Differences in the frequency of symptoms reported by each observer were to be assessed statistically. Details of the interviews were to be investigated from tape-recordings, in order to find ways to improve both the questionnaire itself and the technique of the interview in future surveys.

## Methods

It was decided that a number of subjects were each to be interviewed twice, with a different allocation of subjects to observers on the second occasion. This enabled any discrepancies between the two answers given by the same subject to the same question to be investigated from the tape-recordings. The system of re-allocation enabled differences between observers, in the number of symptoms reported, to be tested for significance. At least 4 weeks elapsed between the two interviews. Kinsey, Pomeroy, and Martin (1948) considered that the answers given by an individual might influence his answers to the same question at a second interview unless at least 8 months intervened. Questions about repiratory symptoms, on the other hand, are not so emotionally charged as those put by Kinsey in investigating sexual behaviour. One of us (C.M.F.) found in a pilot study that hospital patients forgot their previous answers about respiratory symptoms even after one week. In the present survey no recollection of previous answers was apparent during the second series of interviews.

The Questionnaire.—This is shown in Appendix I. The questions concerned cough, phlegm, breathlessness, wheezing, and nasal catarrh, the effect on the chest of colds and the weather, past chest illnesses, and smoking habits. The majority of questions were designed to be answered either "Yes" or "No". For most of the remainder, alternative answers were laid down from which a choice had to be made. A few questions only were open-ended. Most questions (referred to as "compulsory") had to be asked of

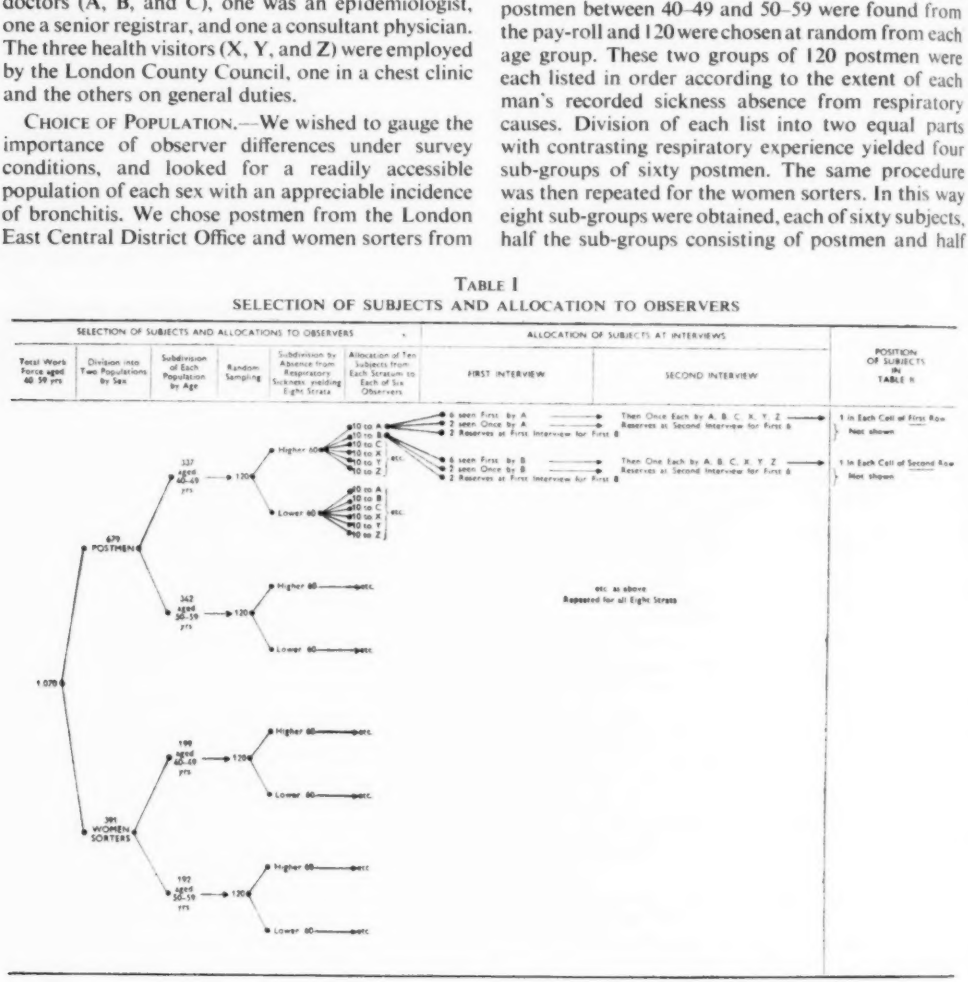
every subject, but some "supplementary" questions were asked only when a particular answer had first been given; *e.g.*, when the answer to the question "Does the weather affect your chest?" was "Yes", the supplementary question "What sort of weather?" was asked.

CHOICE OF OBSERVERS.—Since it is often convenient to employ medical auxiliaries in field surveys, we chose as observers three doctors and three health visitors. This allowed us to compare both the doctors with the health visitors as groups and also the individual observers within each group. Of the three doctors (A, B, and C), one was an epidemiologist, one a senior registrar, and one a consultant physician. The three health visitors (X, Y, and Z) were employed by the London County Council, one in a chest clinic and the others on general duties.

CHOICE OF POPULATION.—We wished to gauge the importance of observer differences under survey conditions, and looked for a readily accessible population of each sex with an appreciable incidence of bronchitis. We chose postmen from the London East Central District Office and women sorters from the Post Office Savings Bank in Hammersmith, London, between 40 and 59 years of age. The detailed sickness absence records of civil servants provided a means of checking the answers concerning past illnesses (Fletcher, Elmes, Fairbairn, and Wood, 1959).

SELECTION OF SUBJECTS AND ALLOCATION TO OBSERVERS.—Subjects were selected by random sampling. Every individual was asked to attend for interview, except for some reserves who were only approached if others failed to attend. The method of sampling and allocation to observers for the first interview is illustrated in Table I. The names of all postmen between 40–49 and 50–59 were found from the pay-roll and 120 were chosen at random from each age group. These two groups of 120 postmen were each listed in order according to the extent of each man's recorded sickness absence from respiratory causes. Division of each list into two equal parts with contrasting respiratory experience yielded four sub-groups of sixty postmen. The same procedure was then repeated for the women sorters. In this way eight sub-groups were obtained, each of sixty subjects, half the sub-groups consisting of postmen and half

TABLE I
SELECTION OF SUBJECTS AND ALLOCATION TO OBSERVERS


SELECTION OF SUBJECTS AND ALLOCATIONS TO OBSERVERS
ALLOCATION OF SUBJECTS AT INTERVIEWS
Total Work Force aged 40–59 yrs
Division into Two Populations by Sex
Subdivision of Each Population by Age
Random Sampling
Subdivision by Absence from Respiratory Sickness yielding Eight Strata
Allocation of Ten Subjects from Each Stratum to Each of Six Observers
FIRST INTERVIEW
SECOND INTERVIEW
POSITION OF SUBJECTS IN TABLE II
1,079
679 POSTMEN
337 aged 40–49 yrs
342 aged 50–59 yrs
120
Higher 60
Lower 60
10 to A
10 to B
10 to C
10 to X
10 to Y
10 to Z
etc.
6 seen First by A
2 seen Once by A
2 Reserves at First Interview for First B
Then Once Each by A, B, C, X, Y, Z
Reserves at Second Interview for First B
1 in Each Cell of First Row
Not shown
6 seen First by B
2 seen Once by B
2 Reserves at First Interview for First A
Then One Each by A, B, C, X, Y, Z
Reserves at Second Interview for First A
1 in Each Cell of Second Row
Not shown
etc. as above
Repeated for all Eight Strata
400 WOMEN SORTERS
199 aged 40–49 yrs
192 aged 50–59 yrs

of women sorters. Six sets of ten subjects from each of the eight sub-groups were then allocated at random to the six observers. In this way a sample of eighty subjects stratified by age, sex, and respiratory sickness absence was allocated to each observer: the eight sub-groups formed by three successive halvings of the whole sample population are called "strata".

Table II shows the allocation to observers of subjects who were seen twice. Of the ten subjects in one stratum allocated to Observer A, six, chosen at random, were to be seen by A at the first interview; and these six subjects were then to be seen, one by each of the six observers, including A himself, at the second interview. If subjects are classified in a $6 \times 6$ Table (as in Table II) according to the observer at each interview, one of these six subjects appears in each of the six cells of the first row. The other four subjects in each set of ten were reserves, and are not shown in Table II. Two of these four reserves were seen once by A during the series of first interviews and could therefore be substituted for any of the first six subjects who were not available at the second interview. The remaining two reserves could be substituted for any of the first eight who failed to attend the first series of interviews.

The same allocation was repeated for all six observers and all eight strata. This completes Table II with eight subject in each of the 36 cells. It also provides 32 reserves, not shown in Table II, for the 48 subjects in each of the six rows, and half of these reserves were interviewed once. 288 subject were thus interviewed twice, and 96 subjects once only.

TABLE II

NUMBER OF SUBJECTS ALLOCATED TO OBSERVERS AT EACH OF TWO INTERVIEWS
(All 288 subjects interviewed twice)

| | | Observer at Second Interview | | | | | |
|---|---|---|---|---|---|---|---|
| | | A | B | C | X | Y | Z |
| Observer at First Interview | A | 8 | 8 | 8 | 8 | 8 | 8 |
| | B | 8 | 8 | 8 | 8 | 8 | 8 |
| | C | 8 | 8 | 8 | 8 | 8 | 8 |
| | X | 8 | 8 | 8 | 8 | 8 | 8 |
| | Y | 8 | 8 | 8 | 8 | 8 | 8 |
| | Z | 8 | 8 | 8 | 8 | 8 | 8 |

Of the 384 subjects chosen for at least one interview, only seven (1·8 per cent.) refused to be interviewed at all and eleven (2·9 per cent.) were not interviewed for other reasons (one through death, and the others through sickness, retirement, or transfer). Of the 288 subjects chosen for a second interview, only one refused (0·3 per cent.) and eleven lapsed for other reasons (3·8 per cent.). Each gap was filled by a reserve from the correct stratum.

BRIEFING.—The three doctors had all contributed to the design of the questionnaire and two of them had used a similar one in a pilot survey. The purpose of each question was explained to the health visitors. At a preliminary session each observer interviewed two hospital patients with chest illnesses. All six observers heard tape-recordings of these interviews and discussed together the interpretation of difficult answers. Written instructions, elaborated to cover any points of difficulty, were given to each observer (Appendix II).

CONDUCT OF THE SURVEY.—The survey began in November, 1956, and was completed in March, 1957. All interviews took place during working hours on Post Office premises, and postmen were seen on night duty when necessary. One of us (C.H.W.), who did no interviewing, recorded the sitting height and the weight of each subject and then made a series of slow and fast vital capacity tracings on a spirometer. The observer then interviewed the subject. The questionnaire was completed, and the observer then measured the peak expiratory flow rate using a Wright Expiratory Flow Meter (Wright and McKerrow, 1959).

After the first interview with the postmen, it was found that a number of "compulsory" questions had been left unanswered on the questionnaires. The percentage of these varied from 0·8 per cent. in the case of Observer Y to 4·8 per cent. in the case of Observer A (Table III). Since the answers to these questions were needed for the statistical analysis, they were obtained by playing back the tape-recording, where this sufficed, or by arranging a fresh interview. At the second interview with the postmen and at all interviews with the women sorters, the written answers were independently checked for completeness by C.H.W. before the subject left. The frequency of uncompleted questions might have been reduced by a better layout of the questionnaire to facilitate checking by the observer at the end of the interview.

TABLE III

UNCOMPLETED ANSWERS

| Observer | Total Answers | Uncompleted Answers | |
|---|---|---|---|
| | | No. | Percentage |
| A | 896 | 46 | 5·1 |
| B | 896 | 32 | 3·6 |
| C | 896 | 25 | 2·8 |
| X | 896 | 52 | 5·8 |
| Y | 896 | 7 | 0·8 |
| Z | 896 | 14 | 1·6 |
| Total | 5,376 | 176 | 3·3 |

TABLE IV
DURATION OF RECORDED PART OF INTERVIEW (IN MINUTES)

| Observer | | | A | B | C | X | Y | Z | All Observers |
|---|---|---|---|---|---|---|---|---|---|
| Interviews with | Postmen | Average | 5·0 | 6·1 | 4·95 | 6·1 | 6·0 | 8·3 | 6·1 |
| | | Range | 2–8 | 2–11·5 | 2·5–8·5 | 3–11·5 | 2·5–12·5 | 5–12 | 2–12·5 |
| | Women Sorters | Average | 4·75 | 7·6 | 4·9 | 5·75 | 4·5 | 8·5 | 6·0 |
| | | Range | 2·5–8 | 3–11·5 | 2–8 | 4–10 | 2–9 | 4–24 | 2–24 |

LENGTH OF INTERVIEWS.—Table IV shows the duration of that part of the interview which was recorded on tape. The average duration for all observers was 6 minutes. This does not include the time spent on informal exchanges at the beginning and at the end of the interview, on taking the smoking history, or on taking the peak flow meter readings. The faster interviewers spent less time on these matters than the slower, thereby increasing the differences between them in the average duration of the whole interview. The average length of time that each subject was away from work was about 20 minutes.

PUNCH-CARDS.—The answers on the questionnaires were transferred on to 65-column punch-cards. It was found more convenient to have one card for each question, rather than to have one card for each subject as is more usual. Separate cards were punched for each of the two series of interviews. If an answer was positive, a hole was punched in the card for that question and for that series of interviews. The position of the hole was the same throughout for any one subject.

The total number of subjects answering "Yes" to a question at one of the series of interviews could be counted from the number of holes in the appropriate card. Cards were also punched to show individuals of different age or of different sex. The numbers in these different groups who answered "Yes" to one or more questions could be counted from the number of coincident holes when the corresponding cards were exactly superimposed. Additional cards could be punched to show individuals with any combination of characteristics. It was found useful to punch a number of negative cards in order to show those subjects who answered "No" to certain questions.

Cards of two contrasting colours were used for the two series of interviews, and enabled disagreements between the two corresponding answers by the same subject to be counted. The number of subjects who answered "Yes" at the first interview, and "No" at the second, could be found by placing the first interview card on top of the second interview card, and counting the number of dots where the colour of the second card showed through the holes in the first card. Those subjects who answered "No" at the first interview and "Yes" at the second could be counted in a similar way by reversing the order of the two cards.

METHOD OF STATISTICAL ANALYSIS.—The analysis was restricted to those subjects who were interviewed twice, and to questions which were answered by every subject in one of two alternative ways at each interview. The answers to twenty important compulsory questions, requiring the answer "Yes" or "No", were analysed. In four instances, the subject was classified in the same way by combining more than one answer. A subject who answered "No" to Question 31, "Does the weather affect your chest?" was then asked a "check" question, "Not even fog or cold?" (Question 31a). The answer "Yes" to either Question 31 or Question 31a was counted as positive, and the answer "No" to both questions as negative. The answers to Questions 43 and 43a were combined in the same was as those to Questions 31 and 31a. Subjects with breathlessness Grade 2 and over (Question 17) were considered as positive and those with Grade 1 as negative. An answer to part (*a*) of Question 29, "Do colds go to your chest?", was counted as negative, and an answer to part (*b*) as positive. At the first interviews with the postmen, Questions 4, 5, 9, and 10 (cough and phlegm during the day) were asked only if the answer to Question 2 (cough on rising) was positive. The data on these four questions were therefore incomplete and could not be analysed.

Systematic differences between observers in the number of positive answers reported to each question were tested for significance by analysis of variance. The quantity analysed was the difference in the total number of positive answers to one question given by the same subjects at the two interviews. The method of analysis is described in Appendix III.

## RESULTS

The systematic tendencies of each observer are shown in Table V (opposite) and in Fig. 1 (overleaf).

TABLE V

PREVALENCE OF RESPIRATORY SYMPTOMS REPORTED BY THREE DOCTORS (A, B, C) AND THREE HEALTH VISITORS (X, Y, Z)

Percentage positive answers from a combined population of 288 subjects, 144 London postmen and 144 women sorters aged 40–59 years; adjusted

| Question | Doctors (D) | | | Health Visitors (HV) | | | Significant Differences between Observers |
|---|---|---|---|---|---|---|---|
| | A | B | C | X | Y | Z | |
| (1) Cough usually | 26·4 | 21·2 | 22·2 | 26·4 | 28·5 | 27·4 | |
| (2) Cough on rising (Winter) | 38·0 | 24·5 | 33·9 | 33·9 | 41·1 | 44·3 | |
| (3) Cough on rising (Summer) | 20·1 | 13·9 | 22·2 | 21·2 | 25·3 | 30·6 | HV > D * |
| (6) Phlegm usually | 30·2 | 29·2 | 28·1 | 32·3 | 20·8 | 34·4 | |
| (7) Phlegm on rising (Winter) | 30·7 | 24·5 | 24·5 | 30·7 | 35·9 | 38·0 | HV > D * |
| (8) Phlegm on rising (Summer) | 10·4 | 16·7 | 15·6 | 20·8 | 15·6 | 33·3 | Z > X, Y * |
| (17: 2–5) Breathlessness | 33·5 | 31·4 | 23·1 | 37·7 | 16·8 | 21·0 | X > Y, Z ** |
| (18) Breathing better in Summer | 35·4 | 26·0 | 10·4 | 18·7 | 27·1 | 13·5 | A > B, C **<br>A, B > C ** |
| (20) Breathing varies day to day | 9·9 | 8·9 | 9·9 | 6·8 | 12·0 | 18·2 | Z > X, Y *<br>Y, Z > X * |
| (21) Wheezing occasionally | 63·0 | 54·7 | 51·6 | 57·8 | 50·5 | 56·8 | |
| (23) Wheezing frequently | 10·7 | 8·6 | 11·8 | 8·6 | 11·8 | 12·8 | |
| (24) Symptoms of asthma | 17·5 | 1·9 | 3·0 | 3·0 | 7·1 | 16·5 | A > B, C **<br>Z > X, Y ** |
| (29) Colds go to chest | 40·8 | 36·6 | 40·8 | 33·5 | 34·5 | 27·3 | D > HV * |
| (31) Weather affects chest | 35·4 | 27·1 | 26·0 | 35·4 | 27·1 | 30·2 | |
| or 31a: Not even fog? | 53·1 | 47·9 | 31·2 | 42·7 | 36·5 | 44·8 | A, B > C ** |
| (41) Nasal catarrh (Winter) | 42·9 | 35·6 | 30·4 | 35·6 | 30·4 | 51·2 | Z > X, Y ** |
| (42) Nasal catarrh (Summer) | 23·1 | 25·2 | 20·0 | 33·5 | 13·7 | 23·1 | X > Y, Z **<br>X, Z > Y ** |
| (43) Chest illness last 3 years | 39·2 | 37·2 | 38·2 | 48·6 | 31·9 | 40·3 | |
| or 43a: Not even 'flu? | 60·8 | 51·4 | 52·4 | 53·5 | 47·2 | 55·6 | |
| (57) History of pneumonia | 12·0 | 16·1 | 17·2 | 13·0 | 14·1 | 12·0 | |
| (58) History of pleurisy | 10·2 | 10·2 | 10·2 | 9·2 | 9·2 | 6·0 | |
| (60) History of other chest illness | 12·0 | 15·1 | 12·0 | 10·9 | 17·2 | 23·4 | Z > X, Y * |
| (61) Heart trouble | 6·8 | 1·6 | 4·7 | 2·6 | 7·8 | 4·7 | |
| (62) Do you smoke? | 61·2 | 60·2 | 60·2 | 59·2 | 60·2 | 60·2 | |

* = Differences significant at 5 per cent. ** = Differences significant at 1 per cent.

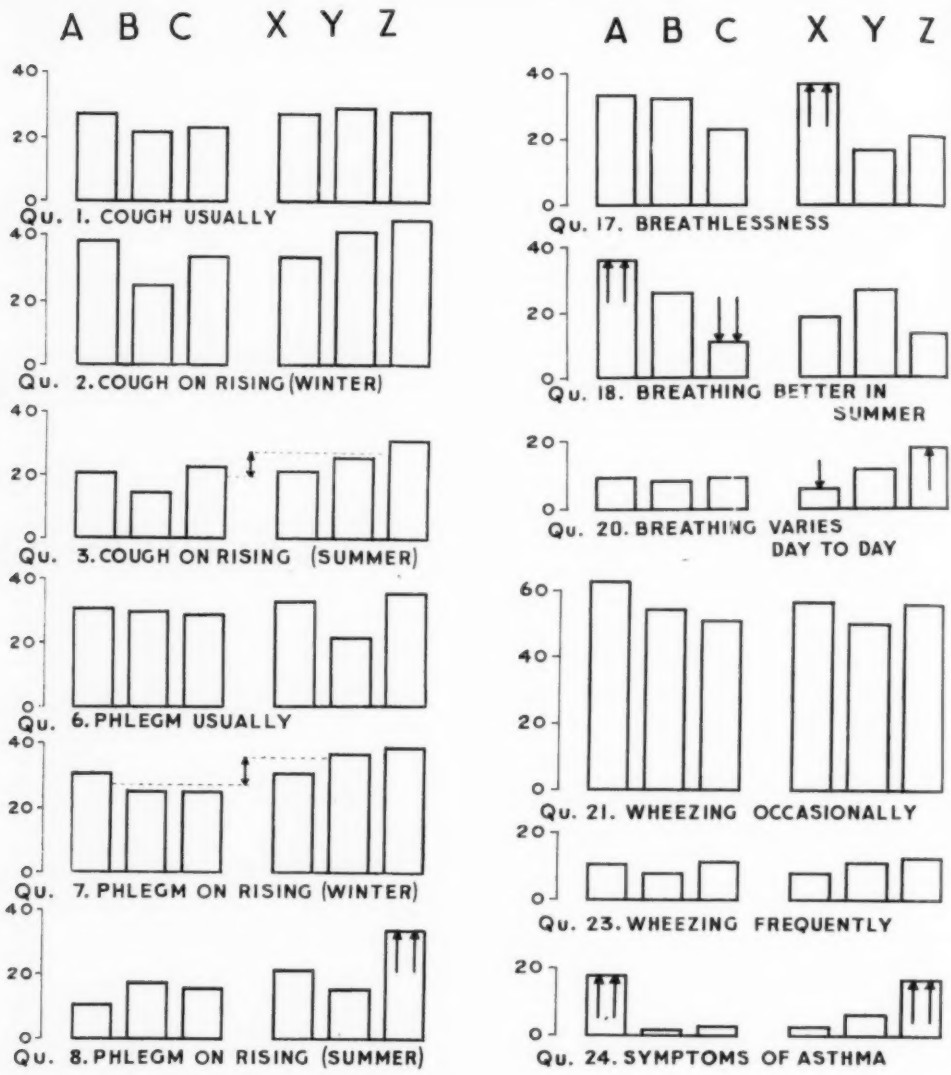

A B C X Y Z
Qu. 1. COUGH USUALLY
Qu. 2. COUGH ON RISING (WINTER)
Qu. 3. COUGH ON RISING (SUMMER)
Qu. 6. PHLEGM USUALLY
Qu. 7. PHLEGM ON RISING (WINTER)
Qu. 8. PHLEGM ON RISING (SUMMER)
A B C X Y Z
Qu. 17. BREATHLESSNESS
Qu. 18. BREATHING BETTER IN SUMMER
Qu. 20. BREATHING VARIES DAY TO DAY
Qu. 21. WHEEZING OCCASIONALLY
Qu. 23. WHEEZING FREQUENTLY
Qu. 24. SYMPTOMS OF ASTHMA

FIG. 1.—Prevalence of respiratory symptoms reported by three doctors (A, B, C) and three health visitors (X, Y, Z). Percentage positive answers from a combined population of 288 subjects, 144 London postmen and 144 women sorters aged 40–59 years; adjusted.

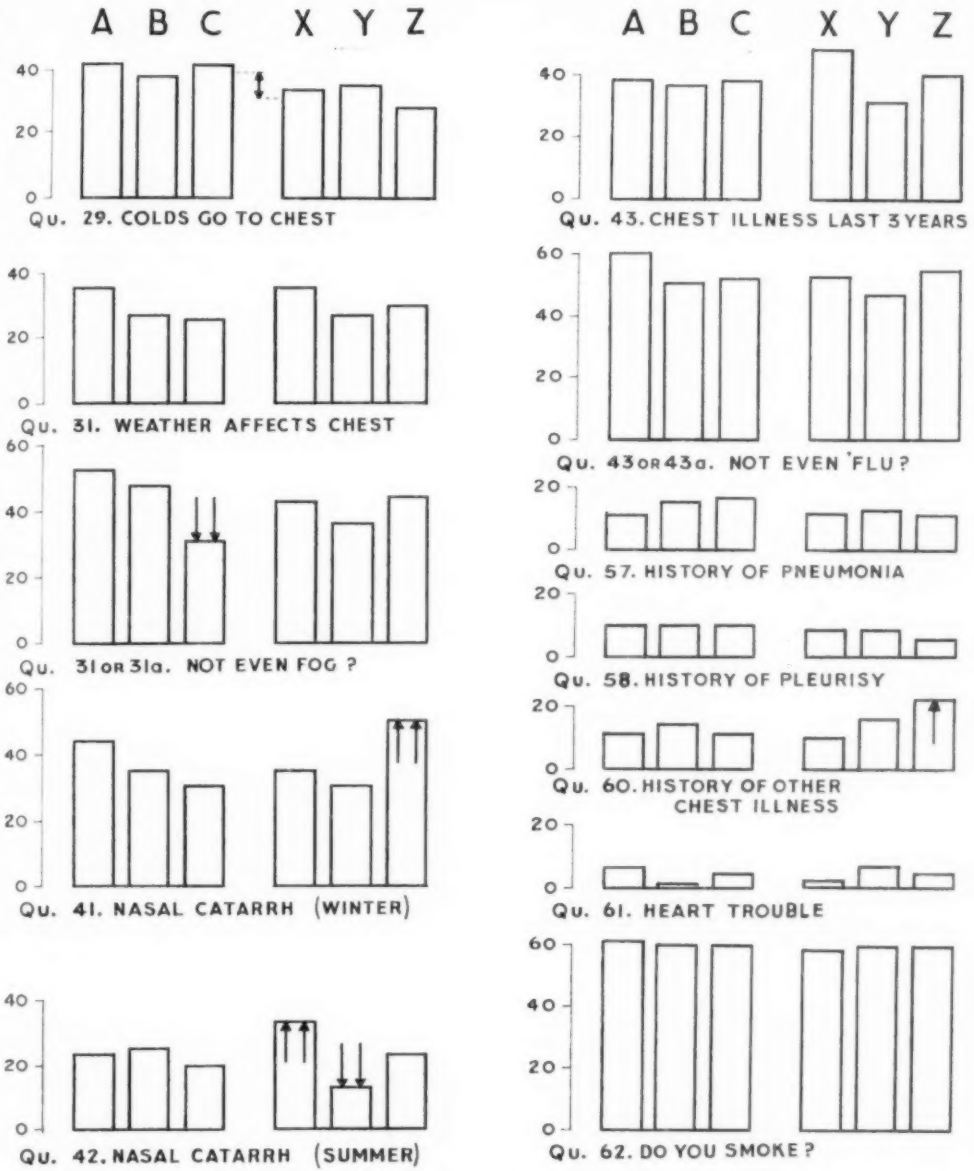

A B C X Y Z
40
20
0
Qu. 29. COLDS GO TO CHEST
Qu. 31. WEATHER AFFECTS CHEST
60
Qu. 31 or 31a. NOT EVEN FOG ?
Qu. 41. NASAL CATARRH (WINTER)
Qu. 42. NASAL CATARRH (SUMMER)
Qu. 43. CHEST ILLNESS LAST 3 YEARS
Qu. 43 or 43a. NOT EVEN 'FLU ?
Qu. 57. HISTORY OF PNEUMONIA
Qu. 58. HISTORY OF PLEURISY
Qu. 60. HISTORY OF OTHER CHEST ILLNESS
Qu. 61. HEART TROUBLE
Qu. 62. DO YOU SMOKE ?

FIGURE 1.

Table V and the four parts of Fig. 1 show for each question the percentage of positive answers reported among all the subjects, both postmen and women sorters, interviewed by each observer. Comparison of the prevalence rates actually found by observers is often misleading, because each observer has interviewed different subjects. Observer Z, for instance, saw the 48 subjects in the last row of Table II at their first interview, and the 48 subjects in the last column of Table II at their second interview. At these 96 interviews she reported 52 positive answers to Question 2, a prevalence rate of 54·2 per cent. Now all six observers at both interviews reported 207 positive answers to the same question at 576 interviews, a rate of 35·9 per cent., so that Z appears to have over-reported the prevalence of this symptom by 18·3 per cent. But all six observers shared equally the second interviews with the subjects in the last row of Table II, and the first interviews with those in the last column. At these 96 interviews, 44 positive answers were reported, so that all six observers seeing the *same* subjects as Z reported a prevalence rate of 45·8 per cent., less by only 8·4 per cent. than that found by Z. The very high prevalence rate in Question 2 found by Z compared with the general average was in fact largely due to the chance allocation to her for interview of a group of subjects with a high prevalence of symptoms. In order, therefore, to show each observer's tendency to over- or under-report symptoms among the *same* subjects, every prevalence rate which is shown in Table V and Fig. 1 and which is discussed throughout the text has been corrected for these sampling variations between the subjects seen by different observers. The actual rate found by each observer has been adjusted by the difference between the rate found by all six observers at all 576 interviews, and that found by all six observers among the *same* subjects as that particular observer. Z's "adjusted" prevalence rate in Question 2 is therefore $54·2 + (35·9 - 45·8) = 44·3$ per cent. This method of adjustment was only made possible by the special design of this survey and is not of general application.

Significant differences between the prevalence of symptoms reported by observers are shown in Table V and Fig. 1. The same system of comparing observers was adopted throughout. The statistical significance of any group difference between doctors and health visitors, and of every individual difference between each observer and the other two in the same group was tested for each question. There are theoretical objections to this method of individual comparison (see Appendix III), but it gives a sufficient indication for practical purposes of the relative frequency and direction of real differences between the observers. Too much importance must not in any case be attached to one significant effect. A number of these may occur by the operation of chance, the choice of a significance level is itself arbitrary and alternative methods of analysis may not give quite the same results.

Significant group differences between doctors and health visitors occurred in four questions. (A technically significant group difference in Question 8 was due solely to the high prevalence reported by Z and is not shown in Fig. 1.) Health visitors reported more of the population as having morning cough in summer (Question 3) and more as having morning sputum in winter (Question 7), than did doctors. Doctors reported more colds going to the chest (Question 29). These three group differences were only significant at the 5 per cent. level. The difference in the prevalence of symptoms reported by each group amounted in each case to between 5 and 10 per cent. of the subjects interviewed. For instance, doctors found 27 per cent. of subjects to have morning sputum in winter, while health visitors found 35 per cent., a difference of 8 per cent. Health visitors also reported more positive replies to the three other questions on cough and sputum (1, 2, and 6) which were analysed, but the difference is not formally significant in any one question. Reasons for these differences are advanced later.

There were thirteen significant individual differences. Four of these occurred between the doctors. A reported a higher prevalence than B and C together in Questions 18 and 24. C reported a lower prevalence than A and B in Questions 18 and 31/31a. Nine significant differences occurred between health visitors. Z reported a higher prevalence than X and Y in five questions (8, 20, 24, 41, and 60). X over-reported as compared with Y and Z in Question 17 (grades 2–5) and in Question 42 and under-reported in Question 20. Y under-reported as compared with X and Z in Question 42.

Ten out of these thirteen individual differences were highly significant at the 1 per cent. level, and in these cases the difference in the prevalence of symptoms reported amounted to between 10 and 20 per cent. of the subjects interviewed. For instance, C found that the chest was affected by the weather in 31 per cent. of subjects (Question 31/31a) while A and B found this in 51 per cent. X found breathlessness Grade 2 or more (Question 17) in 38 per cent.

of subjects, while Y and Z found it in only 19 per cent. Significant over-reporting by one observer compared with the other two of the group (nine occasions) was commoner than under-reporting (four occasions).

These significant differences between individual observers suggest that A and Z were tending generally to report more symptoms, and C and Y less symptoms, than the other observers in their groups. This is borne out by a comparison, set out in Fig. 2, of the prevalence of symptoms reported by each observer, averaged for all 24 questions, among the postmen and among the women sorters. The systematic differences between the six observers in the average of the prevalence rates which they reported in each population are similar. The average prevalence rate found by A was in each case 4–5 per cent. greater than that found by C: A generally found 33·4 per cent. of the postmen to have symptoms, and C found 29 per cent.; A found 22·3 per cent. of the women sorters to have symptoms, while C found 17·4 per cent. In the same way Z generally found a higher prevalence of symptoms in each population than Y. This difference was about 3 per cent. in postmen (31·3 per cent. compared with 29·2 per cent.), but rather larger (5·6 per cent.) in the women sorters (23·9 per cent. compared with 18·3 per cent.). B and X were intermediate between the other observers in each group in their estimate of the level of symptoms in both populations.

In this statistical analysis, one effect of the differing techniques of observers has been studied, namely systematic differences between them in the number of positive symptoms reported. It must be remembered, however, that these systematic differences between observers do not show the full extent of the disagreements between their answers. If for example the number of subjects who answered "Yes" to the first observer and "No" to the second, in the same question, was equal to the number who answered "No" to the first and "Yes" to the second, each observer would report the same number of positive answers, yet the number of differing answers might be considerable. Nor do faults in observers' technique necessarily lead to systematic differences between the prevalence rates which they report. One observer may, for example, be given to different faults both of over- and under-reporting in the same question, the numerical effects of which cancel each other out; or two observers may be given to faults in the same direction which leave the differences between them unchanged.

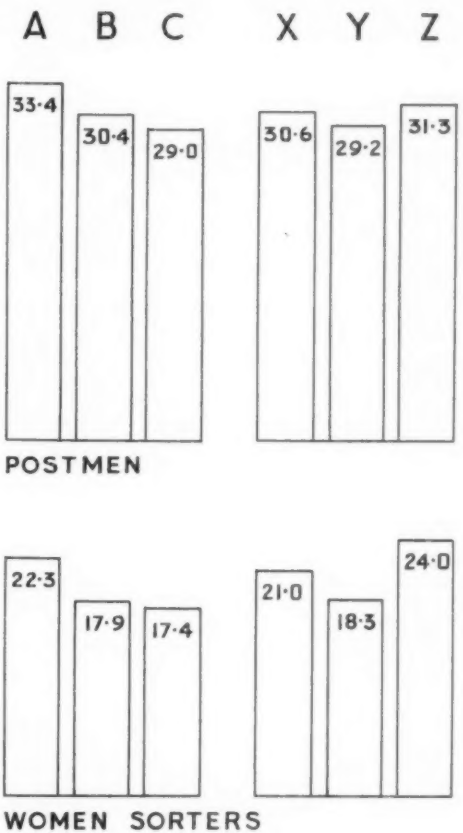



FIG. 2.—Prevalence of respiratory symptoms reported by three doctors (A, B, C) and three health visitors (X, Y, Z). Average of 25 different symptoms found in a combined population of 288 persons, 144 London postmen and 144 women sorters; adjusted.

TAPE-RECORDINGS.—The object of recording the interviews on tape was to find the reasons for disagreement between the answers obtained by two observers from the same subject to the same question. It was hoped in this way to explain the discrepancies between the symptom prevalence found by different observers, to assess the frequency of different causes of error, and to find ways to improve the phrasing of questions and the briefing of observers in future surveys.

Each subject was reassured that the interview was confidential and that the only purpose of the tape-recordings was to check the answers that the observers were writing down. All but two subjects consented to the interview being recorded, and in most cases no notice seemed to be taken of the machine.

160 disagreements were chosen at random from the answers to twelve questions in which the prevalence rates obtained by different observers differed significantly. The divergent answers were identified from the punch-cards. The recordings of the relevant parts of both interviews were played back from the tapes and transcribed in pairs on to master sheets, so that the reasons for the different answers might be discovered.

Observers had been briefed to use the exact wording of each question where possible and to record a definite answer as such. A "probing" question was required if the first answer was vague or on the borderline, but such questions were not to "force", *i.e.* to suggest the answer to the subject. If, after probing, the answer was still uncertain, it was then to be reported as negative. Examples of failure to observe these rules and of other reasons for disagreement are given below.

*Question 3:*

*Do you cough at all when you get up, or first thing in the morning, in the summer?* .. YES/NO

In Questions 1 and 6, the written instructions defined "usually" in borderline cases as "for most days for at least 3 months in the year". Observers had been instructed verbally that the same criterion of persistence should also apply to all questions about cough and phlegm. Symptoms of shorter duration, for instance with a cold, were to be excluded.

In one-third of the disagreements, the subject gave definite yet different answers to the correctly-asked question at the two interviews. Where the fault lay with the observer the commonest error was in assessing the persistence of the cough during the year. The health visitors, who as a group reported an excess of positive answers, interpreted vague answers such as "quite often" or "sometimes" as positive, without confirming that the cough was experienced "for most days for at least 3 months in the year". Coughs occurring only with colds were also incorrectly reported as positive.

Similar errors also gave rise to significant over-reporting by health visitors in Questions 7 and 8.

*Question 17:*

*Grade 1: Are you ever troubled by breathlessness except on strenuous exertion?*

*Grade 2: (If yes) Are you short of breath when hurrying on the level or walking up a slight hill?* .. .. ..

*Grade 3:* Etc. .. .. .. ..

If the first question was answered "No", the subject was put in Grade 1. If "Yes", the other questions were asked until a "No" was obtained and the grade was recorded as that opposite the last "Yes" received. Observer X overestimated the prevalence of breathlessness. Compared with the others, she placed too many subjects in grades other than 1 because, contrary to the rules, she often asked about Grades 2 and 3 and got anomalous positive answers when she had already had a negative answer to the first part of the question.

*Question 18:*

*Is your breathing better in summer?* .. YES/NO

There was no special briefing about this question. Disagreements mostly arose from radically different answers at each interview. There was no apparent reason for excessive prevalence reported by A.

*Question 24:*

*In the past have you ever had attacks of wheezing and breathlessness, in between which your breathing was quite normal?* .. YES/NO

This question was intended to discover those subjects who had suffered from spasmodic asthma. It was hoped that, by avoiding the word "asthma" and describing the symptoms, the question would mean the same thing to each subject. In fact, the question was so complex that many subjects seemed to answer "yes" without grasping its meaning. Some observers reported these answers as positive on the grounds that no supplementary questions were to be asked when a definite answer was given. Others went on to explain the meaning of the question to the subject and often got a negative answer. Observers A and Z, who over-reported compared with the others, also accepted as a positive answer a history of wheezing and breathlessness with a cold or with bronchitis. This was strictly correct according to the wording of the question, yet other observers realized that the question was not intended to include such cases and were reluctant to report them as positive. The fault here appeared to lie in a badly designed question.

*Question 29:*

*When you have a cold in your head, does it go to your chest?*

(*a*) *Never or only occasionally?* .. ..

(*b*) *Usually or always?* .. .. ..

A cross had to be put in the space opposite one part of the question only. Part (*a*) was treated as negative and part (*b*) as positive. According to the instructions, a cold "going to the chest" should have been followed by cough and phlegm. "Usually" implied that more than half the subjects' colds went to the chest, "occasionally" implied less than half.

The doctors, who reported significantly more colds as going to the chest than the health visitors, sometimes failed to offer the proper alternatives of "occasionally" or "usually", and so forced an answer. One observer, for instance, offered the alternatives "usually" or "always", both of which are in category (*b*). This sort of error arose partly from the fact that the question as written could not be asked in an easy conversational manner. One subject answered "Frankly, I'm fortunate that way. I very rarely get a cold in the head—if I do, it does end on the chest". This was wrongly interpreted as "never or occasionally". "Usually or always" was the correct answer because although colds were rare, more than half of them affected the chest.

*Questions 31 and 31a:*

(*31*) *Does the weather affect your chest?* .. YES/NO
(*31a*) (*If No, check: "Not even fog or cold?"*) YES/NO

No special instructions had been given about the interpretation of these questions, but the effect on the chest had subsequently to be determined in answer to Questions 35–39, and an effect on the nose, throat, or head should clearly not count as an effect on the chest.

The answers to Question 31 were analysed and no significant differences were found between the prevalence of positive answers found by different observers. The answers to Questions 31 and 31a were also combined. "Yes" in this case meant a positive answer to either question, and "No" a negative answer to both. A and B reported significantly more positive answers than C to both questions taken together. Their excess was due to the second "check" question (31a). They wrongly accepted replies such as "Well, I might catch a cold if it was foggy" as positive, without further inquiry as to the nature of the "cold". Some subjects said that their chest was affected, yet were unable to say in what way in answer to Questions 35–39. Observers often ignored the ruling that vague answers, not clarified even after probing, should be counted as negative. One striking example of "forcing" was recorded. The observer, a doctor, thought from the previous answers that the subject was bronchitic, and that his chest should be affected. In spite of the answer "No" to both Questions 31 and 31a, he persevered and obtained a reluctant "Yes" to "Not even a real pea-souper?" Clinical experience may lead an observer to form an opinion about the subject's condition as the interview proceeds. This episode suggests that it may also tempt him to deviate from the rules by forcing the subject to give the expected answer.

*Questions 41 and 42:*

*Apart from colds do you usually have a stuffy nose or catarrh at the back of your nose?*

(*41*) *In the winter?* .. .. .. YES/NO
(*42*) *In the summer?* .. .. .. YES/NO

Observer Z over-reported in Question 41, and Observer X in Question 42. The reason in each case was failure to exclude symptoms which only occurred with colds. Other observers found on probing that many indefinite positive answers related only to colds and correctly reported them as negative.

*Questions 57–60:*

*Apart from the past 3 years have you ever had:*

(*57*) *Pneumonia?* .. .. .. .. YES/NO
(*58*) *Pleurisy?* .. .. .. .. YES/NO
(*59*) *Tuberculosis?* .. .. .. YES/NO
(*60*) *Other Chest Disease?* .. .. YES/NO

Observer Z over-reported in Question 60. Her interviews were carried out more slowly and possibly gave more opportunity for recollection of minor illnesses. On some occasions of disagreement the subject volunteered a history of disease to Z and not to the other observer. On other occasions Z herself reminded the subject of a disease that had been mentioned earlier in the interview.

To assess the relative importance of different causes of disagreement, a further 149 disagreements were randomly selected from the answers to nine important questions and investigated in the same way. The results are shown in Table VI. 62 per cent. of the disagreements were classified as "due to the observer", *i.e.* at one of the two interviews the question was asked incorrectly or the answer misinterpreted. The remaining 38 per cent. of the disagreements seemed to be beyond the observer's control. About half of these were "due to the subject", *i.e.* radically different answers were given on each occasion to correctly asked questions. The rest were "due to the question", *i.e.* the question having been asked and answered correctly, the answer was on the borderline and could not be clarified by further probing. The answers were classified by the one of us (C.H.W.) who had not been an observer.

TABLE VI

CAUSES OF 149 DISAGREEMENTS IN NINE QUESTIONS

| Disagreement due to | No. | Percentage |
|---|---|---|
| Observer .. .. .. | 93 | 62 |
| Subject .. .. .. | 32 | 21 |
| Question .. .. .. | 24 | 16 |
| Total .. .. .. | 149 | 100 |

The three observers independently checked the results and found them to be substantially correct (Table VII, overleaf). The proportions of these causes of disagreement varied between questions, *e.g.* 80

per cent. of the causes of disagreement lay with the observers in Question 6, "Do you usually bring up phlegm from your chest?", whereas only 28 per cent. of causes lay with the observers in Question 17, "Do you have to walk slower than most people on the level?". These errors of technique by observers gave rise to positive answers four times more often than to negative answers.

TABLE VII

INDEPENDENT CLASSIFICATION OF CAUSES OF 102 DISAGREEMENTS IN FIVE QUESTIONS

| Disagreement due to | Classification by One Observer | Check Classification by 3 Observers |
|---|---|---|
| Observer .. .. .. | 78 | 74 |
| Subject .. .. .. | 16 | 23 |
| Question .. .. .. | 8 | 5 |
| Total .. .. .. | 102 | 102 |

In a small number of disagreements (about 3 per cent.), the technique of questioning was correct but the wrong answer was written down by mistake by one of the observers.

## DISCUSSION

The purpose of a questionnaire on respiratory symptoms is to compare their prevalence and to follow their rate of progression in populations with different characteristics. The data are thus used for quantitative *comparison* between *groups*. This contrasts fundamentally with the usual objective of clinical medicine, a *decision* about an *individual*. Here an accurate diagnosis of the patient's condition is of first importance in order to determine the correct treatment or prognosis. In surveys of prevalence, on the other hand, valid comparisons can be made with less accurate data, provided that a sufficient population is studied, and that inaccuracies of reporting are randomly distributed between the groups being compared.

Accuracy of reporting is still desirable in prevalence surveys for several reasons. The most serious type of inaccuracy is caused by errors in the observer's own technique, because this may introduce bias and vitiate comparison of his results with those of other observers. Until the technique of interview can be improved it is important, therefore, to determine the likely extent of such systematic variation between observers, and to take precautions to avoid its effects.

Our results showed that two observers, A and C, differed from each other in the average of their estimate of the prevalence of 24 different symptoms in the whole population by about 5 per cent. (Fig. 2). In a single question, the greatest difference between the prevalence rates estimated by two different observers was 25 per cent.: in Question 18, A found 35·4 per cent. of subjects to have better breathing in summer, and C found only 10·4 per cent. If the three doctors are compared with the three health visitors in the 24 questions which we analysed, there is little difference in the average of their estimates of the prevalence of positive answers; doctors found 25·1 per cent. and health visitors 25·7 per cent. in the combined population. The largest difference between them in one question was 8·3 per cent. in Question 7: doctors found 26·9 per cent. of subjects to have morning phlegm in winter and health visitors found 35·2 per cent. The effects of these systematic differences between observers may thus be lessened by using several observers and grouping their results.

Much of the variation between the two answers to the same question appeared to be randomly distributed between different observers, and did not, therefore, lead to significant differences between the prevalence rates which they reported. Nonetheless, this random type of variation, though less serious than the systematic variation between two observers, should be reduced wherever possible, because it affects the *reproducibility* of the answers to the question, and hence both their *accuracy* and *discriminatory power*.

Though these several terms are closely related, it is important to keep in mind the distinction between them. The value of the answers to a question depends on their *discriminatory power*, *i.e.* their ability to discriminate between subjects with or without evidence of bronchitis. This has been discussed by Fletcher and others (1959). This *discriminatory power* is affected to an important degree by the *accuracy* with which the subjects describe their symptoms. Unfortunately, owing to the subject's fallibility, it is often impossible to determine the truth about his symptoms. In this case the *accuracy* of his answers can be determined only by their *reproducibility*, *i.e.* the extent to which the same answers are given to a question by the same subjects on two different occasions. Although reproducibility is a necessary condition for accuracy, it must be remembered that the accuracy of a question may be less than is implied by its reproducibility. A subject who swallowed his sputum might persistently deny its production to all questioners. Another, troubled by borborygmi, might think that the sound originated in the chest, and consistently, yet wrongly, admit to wheezing. These reproducible false negative and positive answers further reduce the discriminatory

power of the question. They are less important in the case of objective tests. It is fallacious, therefore, to argue that because symptoms are as reproducible as physical signs they are as accurate or valuable in diagnosis.

*Reproducibility* is usually calculated in inverse form as *percentage disagreement*, *i.e.* the number of subjects who answer differently on two occasions expressed as a percentage of all subjects. In the fourfold table shown in Table VIII this quality is equal to $\frac{100(b+c)}{n}$. In three out of the 24 questions which were analysed (57, 58, and 61), the small prevalence of positive answers reduced the percentage disagreement to a meaningless value. In the other 21 questions, the average percentage disagreement was 14·9 per cent. The greatest value was 24·3 per cent. in Question 21 (occasional wheezing) and the smallest was 2·4 per cent. in Question 62 ("Do you smoke?"). These figures imply substantial differences in the accuracy with which different answers were being reported. It is possible that differences in the discriminatory power of the questions found by Fletcher and others (1959) reflect to a certain extent the relative accuracy of the answers. If this accuracy could be improved, a different assessment of the value of the questions might result.

TABLE VIII

CLASSIFICATION OF *n* SUBJECTS ACCORDING TO THE ANSWER "YES" OR "NO" AT EACH OF TWO INTERVIEWS

| | | Number of Subjects answering at Second Interview | | Total |
|---|---|---|---|---|
| | | Yes | No | |
| Number of Subjects answering at First Interview | Yes | $a$ | $b$ | $a+b$ |
| | No | $c$ | $d$ | $c+d$ |
| Total | | $a+c$ | $b+d$ | $a+b+c+d=n$ |

Much of the inaccuracy with which answers are reported is clearly irreducible by efforts on the part of the observer. Consistent false positive and false negative answers, and some of the random variation in the two answers to the same question cannot be avoided. There is the inevitable difficulty of classifying into discrete categories subjects with a continuous range of severity of symptoms, so that there are borderline answers which can justifiably be interpreted as positive or negative (*i.e.* "error due to the question"). There are also occasions when the subject quite unaccountably gives different replies (*i.e.* "error due to the subject").

On the other hand, the predominant cause of all disagreements between the answers to the same question at two interviews appears to be "error due to the observer", which accounts for about 60 per cent. of these discrepancies (Table VI). Many of these errors by observers appear not to lead to any systematic bias between their results, probably because all observers committed a certain number of errors which affected their reporting of answers to the same extent. For instance, the question in which the proportion of "errors due to the observer" was highest, Question 6, showed no significant difference between the prevalence rates found by different observers. Errors by the observers therefore cause not only systematic differences between them in the prevalence of symptoms reported, but also contribute to the "random" variation between the two answers to one question, and therefore to the general inaccuracy of the answers. It seems reasonable to suppose that a major improvement in the technique of the interview would not only eliminate any systematic bias between different observers, but also increase the accuracy and discriminatory power of the answers to the questions.

Apart from purely clerical errors, the disagreements "due to the observer" arose from failure to keep to the briefing. Observers were told to report as such a definite "Yes" or "No", but to try to clarify vague or borderline answers by "probing". Some forgot this rule and followed a definite answer with unwarranted probing which finally led to the opposite answer. Sometimes the opposite mistake was made, and when the answer was indefinite some observers did not try to clarify it by probing. In another group of cases the observer reworded the written question so as to suggest the answer. This mistake was easily made when, as in Question 29, the question was so worded that it could not be asked naturally. Some of the probing questions were also phrased so as to bias the subject's reply.

A further source of error became apparent in Questions 31 and 31a. The observer sensed from clinical experience that two answers by the same subject were inconsistent. He therefore rephrased the second question and asked it again in order to elicit the expected answer. The reply may possibly have been nearer the truth, but consistency with the replies obtained by other observers was lost. Observer A was tending in general to report more positive answers than the other two doctors (Fig. 2) and it is likely that the answers reported by him to other questions were biased in the same way. Memory is fallible, so that determined efforts to get at the real truth may only increase confusion. The aim in comparative surveys of prevalence should rather be to question in a simple and consistent way and scrupulously to observe the briefing instructions. Interviewers should abstain from unwarranted

probing even when the reply is unexpected. In this way variation in the subject's answers, though not avoided, is lessened, and is randomized between observers so as not to vitiate a comparison of their results. Health visitors or lay interviewers, starting with fewer fixed beliefs about the answers they will get, could quite possibly be trained to report more consistently than doctors. It is relevant that the difference in the number of symptoms reported in this survey by two doctors, A and C, was as great as that between two health visitors, Y and Z (Fig. 2).

The consistency of an observer's results does not necessarily depend on the time taken over the interview. The observer with the fewest disagreements with the other observers was a health visitor. She interviewed at a brisk pace. She asked the first question as the subject sat down and succeeding ones almost before the subject had finished answering. She adopted a matter of fact tone and was sometimes impatient at irrelevant answers. This contrasts with another health visitor who had the most disagreements with the other observers. She took time to put subjects at their ease but in doing so appeared to suggest positive answers. A business-like approach may thus be successful while well-meant efforts to encourage the subject may bias his replies.

Our observers were deliberately given no more and no less briefing than is commonly given on such occasions. Two doctors had had previous experience with a similar questionnaire. One of them had been largely responsible for its construction, and he recorded the fewest positive answers of any of the observers. Errors of observers' technique appeared usually to give rise to positive answers. Training and experience would therefore probably tend to reduce the number of symptoms recorded.

Some of the questions which we used are open to criticism, and contributed to errors by the observers or confusion on the part of the subjects. Some questions were not conversationally worded and the observer therefore rephrased them, but did so in such a way as to suggest the answer. Some questions were too complex and the subject was being asked in effect more than one question at the same time. When interpreting the answers about cough and phlegm, for example, observers readily forgot that the symptoms should persist for "most days for at least 3 months in the year". This error has been avoided in later versions of the questionnaire by the inclusion of a separate question. The inquiry about symptoms of asthma (Question 24) confused both subjects and observers. This question should be split into two or three parts.

The instruction of the new interviewers, the preliminary interviews with hospital patients, and the discussion between all the interviewers were insufficient in our survey to avoid bias due to errors of technique. Moreover, the two most experienced interviewers, A and C, differed as much as any two other interviewers in the prevalence rates which they reported (Fig. 2). We do not consider that the briefing of our interviewers was seriously wrong, but insufficient time was spent both in preliminary interviews with patients and in subsequent discussion of difficult points. Most important of all, a single test interview with a patient was insufficient to make certain that the observers were putting the rules of briefing into practice.

The degree of competence required of interviewers must be judged in the light of the particular circumstances of the survey. If, for example, the results of a single interviewer are to be compared with those of others, avoidance of systematic bias is more important than if the results of several interviewers are first grouped together.

After a full study of the questionnaire and the briefing instructions and discussion with experienced colleagues of any difficulties, the new interviewer should conduct a pilot series of at least ten interviews with subjects likely to show at least some chest symptoms. These interviews can be attended by one or more colleagues who can afterwards discuss critically the technique employed. The interviews can with advantage be recorded on tape so that doubtful points can be studied at leisure by playing back any part of the recording, or it may be more convenient and less embarrassing for a nervous interviewer to see the subject alone and for criticism to be confined to the tape recording. Another method of instruction which could usefully supplement the essential pilot interviews is for the new interviewer to study word for word transcripts of questions and answers where known faults of technique have occurred. Although a written transcript cannot convey important aspects of the interview such as emphasis or tone of voice, yet this method is convenient and obviates the need of a tape-recorder, the transcripts can be studied at leisure and can cover a comprehensive variety of faults. The interviewer might be asked to comment on the transcripts and it should be ensured that he can reliably detect any errors of technique. The transcripts should include about an equal number of questions and answers where the technique has been correct and incorrect.

In this survey, we have been concerned chiefly with the problem of the systematic errors introduced by observers into estimates of symptom prevalence.

A related problem, still largely unsolved, is that of the relative importance of the different questions. The inclusion of some questions must depend, amongst other things, on the circumstances and the purposes of the investigation: the shortest possible questionnaire would sometimes be needed, sometimes a longer and more detailed one would be suitable. We consider, however, that in order to maintain comparability between the results of different workers, some questions should always be included. The wording of the questionnaire, and the method of reporting of replies should be standardised, at least for a period. We have therefore consulted with others concerned in surveys of respiratory symptoms, and we have all agreed upon a questionnaire and instructions which appear to us to be the best in the light of present knowledge.* Modifications will obviously be necessary at a later date as experience increases.

## SUMMARY

Each person in a random sample of 144 London postmen and 144 women post-office sorters aged 40 to 59 was interviewed twice at an interval of 6 weeks. At each interview the same questions about respiratory symptoms were asked by one of three doctors or three health visitors.

The prevalence of symptoms reported by the six observers, both individually and as two groups, was compared, and a number of significant differences were found. The frequency and extent of these differences are estimated. The differences between the number of symptoms reported in the same subjects by two doctors was as great as that between two health visitors.

The causes of disagreement in the answers at the two interviews were investigated from tape-recordings. In 62 per cent. of cases of disagreement, one of the observers failed to abide by the briefing instructions; about half of the remainder were due to radically different replies by the subject and half to the difficulties of interpreting vague or borderline answers.

Failure to observe the rules of briefing tended to increase the frequency of positive answers.

The significance of these results is discussed, and suggestions are made for lessening the effects of observer variability in future surveys.

* Copies of this questionnaire, which is shortly to be published, are available from Dr. C. M. Fletcher, Postgraduate Medical School, Ducane Road, London W.12.

We are indebted to the Post Office authorities for permitting the investigation and for their efficient help in arranging the interviews; and to Dr. W. E. Chiesman and Dr. M. C. W. Long for their continuing encouragement of such surveys among civil servants. We are also happy to acknowledge the goodwill of the Union of Post Office Workers and the Civil Service Clerical Association.

We are grateful to Dr. Richard Doll, Dr. Peter Armitage, and Dr. Ian Sutherland for statistical guidance and criticism, and to Dr. Peter Elmes and the three London County Council health visitors, who participated in the interviews. The method of card-punching is a modification of that used by Mr. E. G. Brisch.

Miss Doreen Bobby did the computing and Mrs. B. M. Hunt drew the diagrams.

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The three following appendices will be found overleaf:

Appendix I. Respiratory Symptoms Questionnaire

Appendix II. Notes on Use of Questionnaire

Appendix III. Method of Statistical Analysis

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## APPENDIX 1

### RESPIRATORY SYMPTOMS QUESTIONNAIRE

INTERVIEWER : A B C X Y Z  INTERVIEW: 1st 2nd

NAME ..... SERIAL NO. ..... SEX .....

ADDRESS ..... BIRTH DATE ..... AGE .....

..... WEIGHT .....kilos

DEPARTMENT ..... STEM HEIGHT .....cms.

OCCUPATION ..... DATE .....

TAPE RECORDER Tape No..... Start at.....

---

**COUGH**

Do you usually have a cough? ... Yes/No 1.

Do you cough at all when you get up or first thing in the morning:
(*a*) in the winter? ... Yes/No 2.
(*b*) in the summer? ... Yes/No 3.

Do you go on coughing during the day:
(*a*) in the winter? ... Yes/No 4.
(*b*) in the summer? ... Yes/No 5.

**PHLEGM**

Do you usually bring up phlegm from your chest? (not from back of nose) ... Yes/No 6.

Do you bring up any phlegm at all when you get up first thing in the morning:
(*a*) in the winter? ... Yes/No 7.
(*b*) in the summer? ... Yes/No 8.

Do you go on bringing it up during the day:
(*a*) in the winter? ... Yes/No 9.
(*b*) in the summer? ... Yes/No 10.

Is this phlegm:

(*a*) always clear white, grey, or blackish? ... 11.

(*b*) occasionally yellow or green, at least in parts? ... 12.

(*c*) usually yellow or green? ... 13.

**ONSET AND DURATION OF COUGH AND PHLEGM**

How long have you had this morning cough/phlegm in the winter:
(*a*) less than 1 year? ... 14.

(*b*) 1 to 3 years? ... 15.

(*c*) more than 3 years? ... 16.

**BREATHLESSNESS** (average in last winter) Grade No. 17.

Grade 1. Are you ever troubled by breathlessness except on strenuous exertion? (No disability) ...

(If yes) Grade 2. Are you short of breath when hurrying on the level or walking up a slight hill (Slight disability)...

(If yes) Grade 3. Do you have to walk slower than most people on the level? Do you have to stop after a mile or so (or after ½ hour) on the level at your own pace? (Moderate disability)...

(If yes to either) Grade 4. Do you have to stop for breath after walking about 100 yards (or after a few minutes) on the level? (Severe disability) ...

(If yes) Grade 5. Are you too breathless to leave the house, or breathless after undressing? (Total disability) ...

Is your breathing better in summer? ... Yes/No 18.
(If yes) Grade in summer—after checking ... 19.
Does your breathing vary from day to day? ... Yes/No 20.

**WHEEZING**

Does you breathing ever sound wheezy or whistling? ... ... ... ... ... ... ... ... ... ... Yes/No 21.

(if yes) (*a*) occasionally (for example when you have a cold)? ... ... ... ... ... ... ... ... [ ] 22.

(*b*) most days (or nights)? ... ... ... ... ... ... ... ... ... ... ... ... [ ] 23.

In the past have you ever had attacks of wheezing and breathlessness, in between which your breathing was quite normal? Yes/No 24.

(If yes) How old were you when the attacks began? ... ... ... ... ... ... ... ... ... ... 25.

Do you still have them? ... ... ... ... ... ... ... ... ... ... ... Yes/No 26.

(If no) How old were you when they stopped? ... ... ... ... ... ... ... ... ... ... ... 27.

**COLDS**

When you have a cold in the head, does it go to your chest? (*i.e.* is it followed by increased cough or phelgm?)

(*a*) never or only occasionally? ... ... ... ... ... ... ... ... ... ... ... ... [ ] 29.

(*b*) usually or always? ... ... ... ... ... ... ... ... ... ... ... ... ... [ ]

**WEATHER**

Does the weather affect your chest? ... ... ... ... ... ... ... ... ... ... ... ... ... Yes/No 31.

(If no, check "not even fog or cold?") ... ... ... ... ... ... ... ... ... ... ... ... Yes/No 31(*a*).

(If yes) What sort? Fog ... ... ... ... ... ... ... ... ... ... ... ... ... Yes/No 32.

Cold ... ... ... ... ... ... ... ... ... ... ... ... ... Yes/No 33.

Other ... ... ... ... ... ... ... ... ... ... ... ... ... Yes/No 34.

Does it make you wheeze? ... ... ... ... ... ... ... ... ... ... ... ... ... Yes/No 35.

Does it make you cough? ... ... ... ... ... ... ... ... ... ... ... ... ... Yes/No 36.

Does it make you bring up phlegm? ... ... ... ... ... ... ... ... ... ... ... ... Yes/No 37.

Does it make you breathless? ... ... ... ... ... ... ... ... ... ... ... ... ... Yes/No 38.

Any other effect? ... ... ... ... ... ... ... ... ... ... ... ... ... ... Yes/No 39.

(If yes to 36 or 37) Does the cough/phlegm clear up entirely when the weather is not (as in 32–34) ... ... ... Yes/No 40.

**NASAL CATARRH**

Apart from colds do you usually have a stuffy nose or catarrh at the back of your nose?

(*a*) in the winter? ... ... ... ... ... ... ... ... ... ... ... ... ... ... Yes/No 41.

(*b*) in the summer? ... ... ... ... ... ... ... ... ... ... ... ... ... ... Yes/No 42

**CHEST ILLNESSES**

During the last 3 years have you had a chest illness which has kept you in bed, off work, or indoors? ... ... ... Yes/No 43.

(If no) check "not even 'flu?" ... ... ... ... ... ... ... ... ... ... ... ... ... Yes/No 43(*a*).

(If yes to 43 or 43(*a*))

(*a*) Did you have increased cough with the illness(es)? ... ... ... ... ... ... ... ... ... ... Yes/No 44.

(*b*) Did you have increased phlegm with the illness(es)? ... ... ... ... ... ... ... ... ... ... Yes/No 45.

(c) Did you have only one such illness? ... ... ... ... ... ... ... ... ... ... ... [ ] 46.

(d) Did you have more than one illness? 2–5, 6–10, 10 + (Ring) ... ... ... ... ... ... ... [ ] 47.

(e) Estimated average duration ... ... ... ... ... ... ... ... ... ... 48.

| | Doctor's diagnoses in the illness(es) | Number of times diagnosed | |
|---|---|---|---|
| | Doctor not seen ... ... ... ... ... ... ... ... | ..... | 49. |
| | No diagnosis ... ... ... ... ... ... ... ... | ..... | 50. |
| (Ring appropriate number | Bronchitis ... ... ... ... ... ... ... ... | ..... | 51. |
| and put the number of ill- | Influenza ... ... ... ... ... ... ... ... | ..... | 52. |
| nesses after each alternative) | Pneumonia ... ... ... ... ... ... ... ... | ..... | 53. |
| | Pleurisy ... ... ... ... ... ... ... ... | ..... | 54. |
| | Asthma ... ... ... ... ... ... ... ... | ..... | 55. |
| | Other (specify) ..... | ..... | 56. |

Apart from the past 3 years have you ever had:

Pneumonia? Age..... ... ... ... ... ... ... ... ... ... ... ... Yes/No 57.

Pleurisy? Age..... ... ... ... ... ... ... ... ... ... ... ... Yes/No 58.

Tuberculosis? Age..... ... ... ... ... ... ... ... ... ... ... ... Yes/No 59.

Other chest disease? ..... Age..... ... ... ... Yes/No 60.

Have you ever had heart trouble? ... ... ... ... ... ... ... ... ... ... ... ... Yes/No 61.

(If yes) Doctor's diagnosis .....

(STOP RECORDER)

**SMOKING**

Do you smoke? ... ... ... ... ... ... ... ... ... ... ... ... ... ... Yes/No 62.

(If no) Have you ever smoked? (Record "No" if less than 1 per day for a year) ... ... ... ... ... Yes/No 63.

(If yes) How much?

| N.B. | | Now | Changes during past 15 years |
|---|---|---|---|
| Weekend | Cigarettes per week ... ... ... ... ... ... ..... | ..... | ..... |
| | Oz. tobacco/week (hand-rolled) ... ... ... ... ... ..... | ..... | ..... |
| | Oz. tobacco/week (pipe) ... ... ... ... ... ... ..... | ..... | ..... |
| | Cigars (number/week) ... ... ... ... ... ... ..... | ..... | ..... |

Age of starting regular cigarette smoking .....

Age of stopping regular cigarette smoking .....

Tape Recorder end at .....

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## APPENDIX II

### Notes on Use of Respiratory Symptoms Questionnaire

Start by introducing yourself as a doctor or nurse. Say that you are going to ask some questions about chest symptoms and that the replies are entirely confidential.

Each section may be prefaced with a few words such as "Now, Mr. ....., I want to ask you about a cough".

*Stick to the* ***actual*** *wording of each question as far as possible.* If the answer to the question is doubtful ask any supplementary questions you like to clarify what the subject means.

Where squares are provided for X to be inserted, the X must only be put in one square, since the answers are alternative and if one is positive the other must be negative.

*Mention the subject's name when you switch on recorder.*

### Individual Questions

#### Cough

The aim is to provide a classification of severity according to those who cough first thing in the morning and those who have a repetitive cough during the day and whether this cough occurs only in the winter or is perennial. Clearing the throat does not count as cough.

*Questions 1 and 6.*—"Usually" means most days for at least part of the day. Transient cough with a cold should be excluded, the cough must last for at least 3 months during the year. The point of these questions is that they have been included in previous epidemiological studies and if they are excluded comparison might be difficult.

*Question 2.*—Even if the answer to 1 is "No", 2 should be asked.

*Questions 2 and 3.*—The words *at all* should be stressed.

*Question 4.*—Only asked if the answer to 2 is positive. The words "go on coughing" imply a frequency of about once an hour or more.

#### Phlegm

Any suitable word can be used instead of phlegm according to local custom, but "phlegm" should come up from the chest and post-nasal discharge is excluded. Some subjects admit to bringing up sputum without admitting to cough. This claim should be accepted and it is not necessary to change the answers under cough if they are negative but the answers to phlegm are positive. If phlegm is coughed from the chest and is swallowed, this counts as positive.

*Question 7.*—To be asked even if the answer to 6 is negative.

*Question 9.*—To be asked only if answer to 7 is positive.

*Questions 11–13.*—If the phlegm is stated to be "grey, etc.", the alternative of 12 must be asked to be sure that the phlegm is *always* mucoid.

*Questions 14–16.*—Remember that the coronation was three years ago.

#### Breathlessness

*Question 17.*—*This refers to average condition this winter.* If Grade 1 is answered "No", this is the grade. After that, go on asking till you get a "No". The grade is the last one to which the answer is "Yes" (In the case of Grade 3 *either* question may be answered "Yes").

Write the number of the grade in the appropriate space. Write the grade in summer in the space provided.

*Questions 18–20.*—To be asked in *all* cases. The word "breathing" is preferable to "breathlessness".

#### Wheezing

*Question 21.*—To be asked as written. Whistling is not a separate question.

If subjects are uncertain about the meaning of "wheezing", it may be worth asking whether their relatives, *e.g.* husbands or wives, notice wheezing during the night.

*Questions 22 and 23.*—These are meant to distinguish intermittent wheezing with long periods free from persistent wheezing.

*Questions 24 to 27.*—These are meant to discover subjects who have had occasional asthmatic attacks in the past. In some cases the symptoms will have stopped completely, but in others they may have become persistent. In the latter case, 27 should give the age at which they became persistent.

#### Colds

*Question 29.*—This should be "usually *or always*".

*Questions 30 and 40.*—Only check Questions 2–16 if all of Questions 1–13 have been answered "No". Remember to note the Question (30 or 40) on account of which these questions are checked.

*Questions 35–39.*—If the subject has admitted to cough/phlegm/breathlessness, ask if the weather *makes these worse.*

#### Chest Illnesses

*Question 43.*—Add "at home" after "indoors". Remember these are illnesses since the coronation.

*Question 45.*—Refers only to the illnesses with increased cough/phlegm.

*Question 47.*—Ring the number of illnesses as well as putting the X in the square.

*Question 48.*—Give duration in weeks. If there has been a wide variation give the range, *e.g.* "1 to 13 weeks".

*Question 49 to 56.*—If necessary, offer these diagnoses, *i.e.* say "Was it called bronchitis, 'flu, pneumonia, pleurisy, asthma?"

*Questions 57 to 60.*—If any of these illnesses have been experienced more than once, record all occasions.

## APPENDIX III

### METHOD OF STATISTICAL ANALYSIS

The answers given at two interviews by $n$ subjects to a question requiring the answer "Yes" or "No" can be classified as in Table VIII by a fourfold table. Such a table can be constructed for any number of the 288 subjects in Table II, all of whom were interviewed twice. The smallest possible value of $n$ is 1, and the largest possible value is 288. The difference in the number of positive answers reported among these $n$ subjects at the two interviews is $b-c$; this quantity is positive if more positive answers were recorded at the first interview than at the second. For one subject, $b-c$ can only take the three alternative values $+1$, 0, or $-1$. The variance of $b-c$ can be resolved into its component parts; the sources of variation and degrees of freedom are shown in Table IX. There is no replication in the design, and therefore no term in the analysis of variance corresponding to residual variation. The second order interaction is used as an estimate of residual variance.

TABLE IX

ANALYSIS OF VARIANCE

| Source of Variation | Degrees of Freedom |
|---|---|
| *Main Effects* | |
| Between First Observers (Rows of Table II) | 5 |
| Between Second Observers (Columns of Table II) | 5 |
| Between Strata | 7 |
| *Interactions* | |
| Strata × First Observers | 35 |
| Strata × Second Observers | 35 |
| First × Second Observers | 25 |
| Residual (Second Order Interaction) | 175 |
| Total | 287 |

The total value of $b-c$ for the 48 subjects in the first row of Table II is equal to the number of positive answers reported by A at the first set of 48 interviews, less those reported *among the same subjects* at the second set of 48 interviews, by all six observers, including A himself, who shared these interviews equally between them. This quantity will be positive if A reports a higher prevalence than all the observers, negative if he reports a lower prevalence.

Comparison of the totals of these rows will therefore indicate how each observer over-reports or under-reports symptoms compared with all the observers at interviews with the *same* subjects. Each column total of $b-c$ in Table II affords a similar comparative measure of the tendency of an observer to over- or under-report symptoms, but in this case a *negative* value of $b-c$ represents over-reporting by the single observer and a positive value represents under-reporting.

In any one question, estimates of the variance of $b-c$ derived from the rows or columns of Table II, divided by the residual variance, will yield values of $F$ which can be used to test the significance of differences between observers in the number of positive answers reported.

The two interviewer terms in Table IX, each with five degrees of freedom, can be further subdivided, as shown in Table X. Within each group of three observers there are three alternative ways of comparing one observer with the other two. It was generally found that differences between the mean values of $b-c$ for rows of Table II were of opposite sign to the differences between the corresponding columns. Observers therefore who reported more symptoms than others, as judged by the first interviews, also generally did so at the second. The individual terms in Table X, each with one degree of freedom, can in such cases be recombined, as shown in the last column, by adding the corresponding sums of squares and obtaining a fresh variance estimate based on two degrees of freedom.

TABLE X

SUBDIVISION AND RE-COMBINATION OF OBSERVER TERMS

| Source of Variation | | Degrees of Freedom | | |
|---|---|---|---|---|
| | | First Observers | Second Observers | Re-combined |
| Between Doctors and Health Visitors | | 1 | 1 | 2 |
| Within Doctors | Between A and B, C | 1 | 1 | 2 |
| | Between B and C | 1 | 1 | 2 |
| Within Health Visitors | Between X and Y, Z | 1 | 1 | 2 |
| | Between Y and Z | 1 | 1 | 2 |
| Total | | 5 | 5 | 10 |

The significance of a group difference between doctors and health visitors, and of each of the six individual differences between one observer and the other two in the same group, were tested in each of the 24 questions. The significant results shown in Fig. 1 and Table V were in every case based on a value of $F$ found by combining the difference between the corresponding rows and columns of Table II. This re-combination yielded many significant differences which did not appear from the comparison of either rows or columns alone. In other instances the degree of significance of the differences was increased from the 5 per cent. to the 1 per cent. level. The significance of all first order interactions was tested, but none was found to be significant.

Tukey (1949) has discussed the difficulties of comparing individual means in the analysis of variance. The method of comparing individual observers, used here, somewhat increases the percentage of positive results which would be expected purely by chance, in a series of significance tests, above that of the particular significance level chosen. No satisfactory yet simple method of individual comparison, however, is known. Comparison of one observer with two others leads to simplicity of computing and is satisfactory in practice (see page 178).

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*Brit. J. prev. soc. Med.* (1959), **13**, 194–203

# RESPIRATORY TUBERCULOSIS IN THE BIRMINGHAM REGION*

BY

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With the introduction of the National Health Service in Great Britain in 1948, the Birmingham Regional Hospital Board was formed with responsibility for diagnostic and treatment services for a population of almost four and a half million distributed over five administrative counties and ten county boroughs in the West Midland area of England. With regard to tuberculosis, the Regional Hospital Board became responsible for specialist and hospital services, while prevention and after-care remained the responsibility of the fifteen local health authorities (the counties and county boroughs). The medical care of the patient at home was the responsibility of the third branch of the Service, the general practitioner. The object of this report is to review the changes that have occurred in all aspects of tuberculosis in the 10 years since the introduction of the National Health Service.

## Methods in Use in the Post-War Period

In 1948 the standard method of treatment of pulmonary tuberculosis was a period of rest and graduated exercise in a sanatorium. For cavitated disease that was not extensive, collapse measures were an important part of treatment: collapse might be either temporary, in the form of artificial pneumothorax or pneumoperitoneum requiring air refills at weekly or fortnightly intervals for 2–3 years, or permanent, by major surgery in the form of thoracoplasty or some modification of this procedure.

On the preventive side, the main emphasis lay in the improvement of living conditions, both generally and for the household contacts of known cases of tuberculosis. Intensive and repeated examinations of contacts were necessary to find cases in the earliest possible stages, and mass radiography had been introduced a few years earlier in a further attempt to find cases with disease of limited extent, and to identify unknown sources of infection in the community.

## Methods Introduced in Past 10 Years

The most important change in treatment has been the introduction of drugs effective against tubercle bacilli. Streptomycin was first made available on an experimental basis in 1947, and was followed shortly by para-amino-salicyclic acid (P.A.S.). These remained standard treatment until the introduction of the probably even more effective drug isoniazid in the early part of 1952. The efficacy of these drugs in the treatment of tuberculosis led to demonstrable improvements in some aspects of tuberculosis control, and also made possible other methods of treatment for some patients, including surgical removal of diseased portions of lung. It is largely the influence of this new method of treatment by drugs on other aspects of tuberculosis work that is reviewed here.

On the preventive side, vaccination with B.C.G. was introduced into this region in 1949 for those exposed to special risk of infection, *e.g.* household contacts and hospital workers, and from 1954 local health authorities have been empowered to introduce schemes of vaccination for schoolchildren between their thirteenth and fourteenth birthdays.

## Epidemiology and Prevention

Mortality.—It is well known that deaths from pulmonary tuberculosis have decreased dramatically in recent years. The trends in this Region in death rates per million population for each of five age groups are shown in Fig. 1 (opposite) for men and women respectively, and these rates are also given in Table I (opposite).

* A report prepared for the Regional Advisory Committee on Tuberculosis Services of the Birmingham Regional Hospital Board.

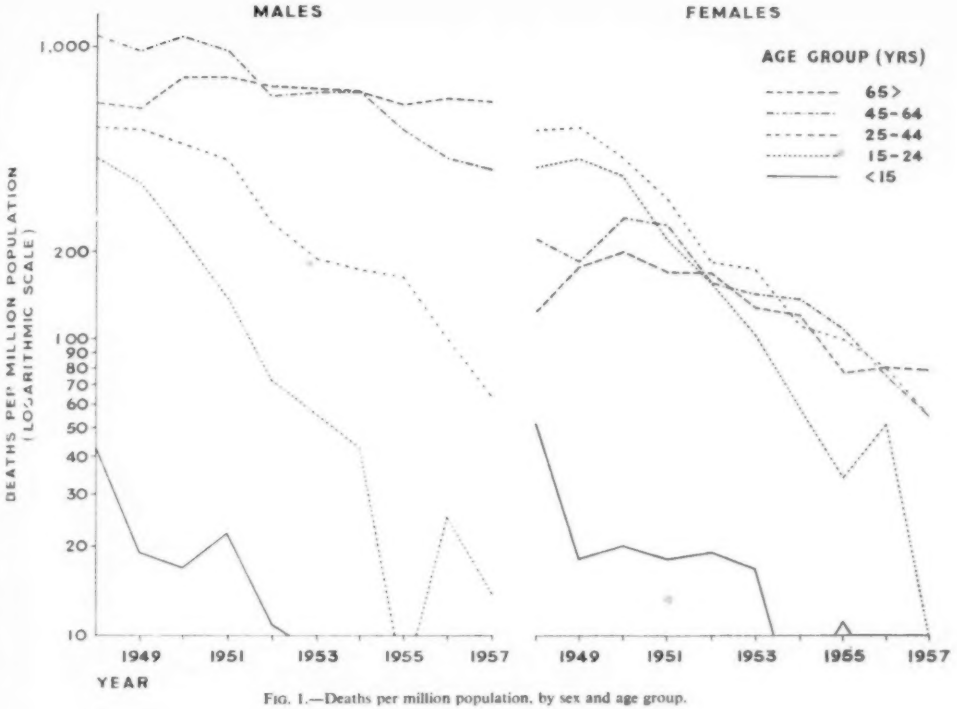


FIG. 1.—Deaths per million population, by sex and age group.

TABLE I

RESPIRATORY TUBERCULOSIS MORTALITY IN THE BIRMINGHAM REGION (1948–57), BY SEX AND AGE
ANNUAL NUMBER OF DEATHS PER MILLION POPULATION

| Year | Age (years) | | | | | | | | | | | | No. of Deaths (all ages) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Under 15 | | 15–24 | | 25–44 | | 45–64 | | 65 and Over | | All Ages | | | |
| | Male | Female | Male | Female | Male | Female | Male | Female | Male | Female | Male | Female | Male | Female |
| 1948 | 44 | 52 | 411 | 391 | 530 | 521 | 1,058 | 220 | 647 | 126 | 522 | 288 | 1,325 | 776 |
| 1949 | 19 | 18 | 345 | 418 | 522 | 533 | 965 | 185 | 606 | 179 | 482 | 284 | 1,136 | 770 |
| 1950 | 17 | 20 | 226 | 358 | 468 | 418 | 1,097 | 261 | 785 | 201 | 490 | 260 | 1,067 | 585 |
| 1951 | 22 | 18 | 139 | 220 | 406 | 306 | 952 | 242 | 791 | 169 | 429 | 199 | 929 | 450 |
| 1952 | 11 | 19 | 72 | 163 | 259 | 188 | 688 | 161 | 739 | 169 | 310 | 138 | 675 | 312 |
| 1953 | 9 | 17 | 56 | 105 | 191 | 175 | 700 | 146 | 711 | 130 | 287 | 118 | 630 | 269 |
| 1954 | 7 | 4 | 42 | 58 | 172 | 115 | 686 | 140 | 689 | 122 | 276 | 89 | 607 | 204 |
| 1955 | 0 | 11 | 7 | 34 | 162 | 100 | 521 | 110 | 625 | 78 | 224 | 71 | 496 | 164 |
| 1956 | 4 | 0 | 25 | 51 | 101 | 81 | 417 | 78 | 672 | 81 | 189 | 58 | 422 | 134 |
| 1957 | 2 | 0 | 14 | 10 | 64 | 55 | 380 | 54 | 645 | 79 | 167 | 39 | 374 | 92 |

A rapidly decreasing trend is evident for each age group and each sex, with the exception of men aged 65 years and over; the 1956 rate for this age group is greater than those for 1948 and 1949, although a gradual decrease has taken place since 1951.

Some deaths from tuberculosis occur in persons not notified before death. Figures for the Region as a whole are not available, but the number of such cases each year in the City of Birmingham (pop. 1,110,000) has shown no tendency to fall, and the position in the Region as a whole is probably little different. Such deaths have amounted to about 4 per cent. of notifications in Birmingham.

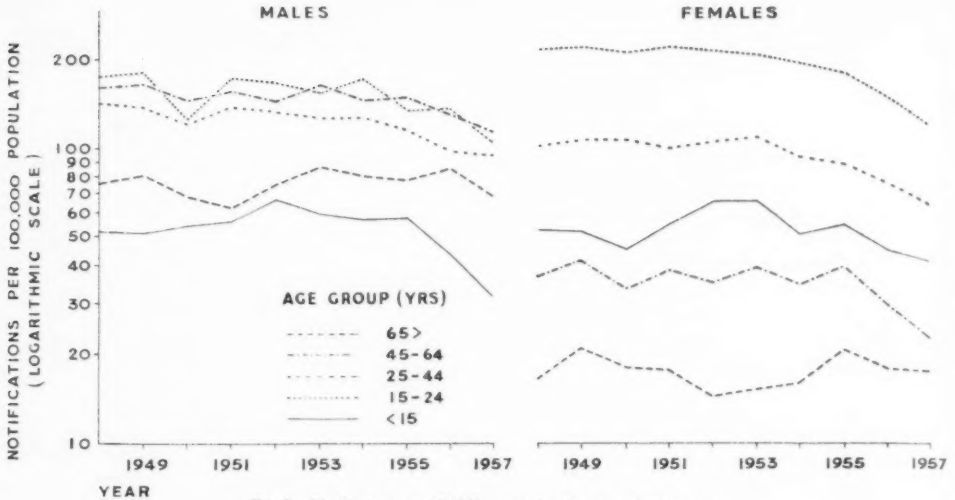


FIG. 2.—Notifications per 100,000 population, by sex and age group.

TABLE II

RESPIRATORY TUBERCULOSIS NOTIFICATION RATES PER 100,000 POPULATION IN THE BIRMINGHAM REGION (1948–57), BY SEX AND AGE

| Year | Age (years) | | | | | | | | | | | | Number of Notifications (all ages) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Under 15 | | 15–24 | | 25–44 | | 45–64 | | 65 and Over | | All Ages | | | |
| | Male | Female | Male | Female | Male | Female | Male | Female | Male | Female | Male | Female | Male | Female |
| 1948 | 51·8 | 52·5 | 178·9 | 215·1 | 143·5 | 102·3 | 164·0 | 36·6 | 74·9 | 16·7 | 124·6 | 81·5 | 2,635 | 1,793 |
| 1949 | 51·1 | 52·4 | 181·0 | 222·3 | 138·3 | 108·9 | 164·4 | 41·5 | 81·0 | 21·3 | 123·6 | 86·0 | 2,662 | 1,926 |
| 1950 | 54·5 | 45·0 | 126·0 | 211·1 | 123·0 | 108·5 | 147·2 | 33·3 | 68·0 | 18·0 | 112·1 | 80·4 | 2,440 | 1,808 |
| 1951 | 56·0 | 55·3 | 170·8 | 221·4 | 139·5 | 99·9 | 158·1 | 38·4 | 61·6 | 17·7 | 120·6 | 82·4 | 2,613 | 1,859 |
| 1952 | 66·5 | 65·4 | 168·3 | 218·0 | 134·9 | 106·1 | 146·8 | 35·0 | 75·6 | 14·5 | 120·0 | 84·5 | 2,612 | 1,915 |
| 1953 | 59·1 | 65·4 | 155·1 | 209·5 | 129·1 | 112·4 | 161·8 | 39·9 | 87·8 | 15·4 | 119·2 | 86·3 | 2,614 | 1,964 |
| 1954 | 57·4 | 50·9 | 173·9 | 196·6 | 129·7 | 93·2 | 145·8 | 34·3 | 80·3 | 16·0 | 117·3 | 74·1 | 2,578 | 1,699 |
| 1955 | 58·2 | 55·5 | 135·7 | 181·2 | 115·6 | 88·0 | 151·4 | 39·7 | 78·3 | 20·5 | 109·5 | 73·2 | 2,422 | 1,685 |
| 1956 | 43·8 | 45·4 | 137·5 | 152·4 | 99·7 | 76·6 | 132·2 | 29·3 | 86·0 | 17·9 | 97·2 | 60·6 | 2,167 | 1,403 |
| 1957 | 31·1 | 41·5 | 108·5 | 123·8 | 95·0 | 65·6 | 113·4 | 22·3 | 68·8 | 17·5 | 83·0 | 51·0 | 1,863 | 1,190 |

NOTIFICATIONS.—The regional trends over the years 1948–57 in the notification rates per 100,000 population in each age group are shown in Fig. 2 for men and women respectively, and the rates are also given in Table II. The male and female rates for all ages showed little change until 1954 when a slow decline began, accelerating in 1957. These findings contrast very strikingly with the trends in death rates. The graphs for age groups show considerable variations within this general pattern.

SOURCES OF NEW CASES.—The relative contributions of the various means of detecting new cases to the total notifications vary from area to area within the Region. However, in most areas referrals from general practitioners, either to mass radiography units or direct to the clinics, account for about half the total notifications. In the Region as a whole, the mean annual proportions in the years 1955–57 inclusive for each source of reference were as follows:

General practitioners 54 per cent. (including 18 per cent. referred to M.M.R. units);
Hospitals 19 per cent.;
M.M.R. (excluding G.P. referrals) 7 per cent.;
Contact service 10 per cent.;
Other sources 10 per cent.

TABLE III

PULMONARY TUBERCULOSIS NOTIFICATIONS IN THE COUNTY OF WARWICKSHIRE (1951–57), BY SEX AND STAGE OF DISEASE

| Sex | | Male | | | | | Female | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Stage of Disease | | Minimal | Intermediate | Extensive | Unclassified | Total | Minimal | Intermediate | Extensive | Unclassified | Total |
| Year | 1951 | 89 | 68 | 45 | 37 | 239 | 65 | 53 | 18 | 45 | 181 |
| | 1952 | 83 | 128 | 34 | 18 | 263 | 89 | 72 | 21 | 15 | 197 |
| | 1953 | 83 | 117 | 49 | 3 | 352 | 104 | 85 | 29 | 3 | 221 |
| | 1954 | 119 | 117 | 34 | 44 | 314 | 82 | 68 | 22 | 11 | 183 |
| | 1955 | 95 | 91 | 44 | 29 | 259 | 83 | 61 | 15 | 12 | 171 |
| | 1956 | 100 | 99 | 45 | 10 | 254 | 102 | 36 | 16 | 7 | 161 |
| | 1957 | 78 | 73 | 28 | 2 | 181 | 72 | 38 | 12 | 1 | 123 |

The mass radiography service therefore accounts for one-quarter of the new notified cases.

In considering these trends it is pertinent to examine the changing picture over the years as regards the stage of disease of newly-diagnosed cases. Such information is not available centrally for the Region as a whole, but in Table III details are given for the county of Warwickshire (pop. 550,000) for 1951–57. As regards men, the number of cases in 1956 at each stage was as high as, or higher than, in 1951, although the number of extensive cases during 1957 was much lower. With regard to women, the number of minimal cases in 1956 was much greater than in 1951, although that for 1957 was about the same; the number of "intermediate" cases decreased from 1955 to 1956 and the number of extensive cases in 1957 did not decrease noticeably.

CLINIC REGISTERS.—The number of cases on the registers of all chest clinics in the Region at the end of each year from 1948 to 1957 is shown graphically in Fig. 3. A considerable increase has taken place since 1951, and the 1957 figure exceeds that for 1951 by more than 50 per cent. However, the 1957 figure is almost the same as that for the previous year, so that this increasing trend has possibly been terminated.

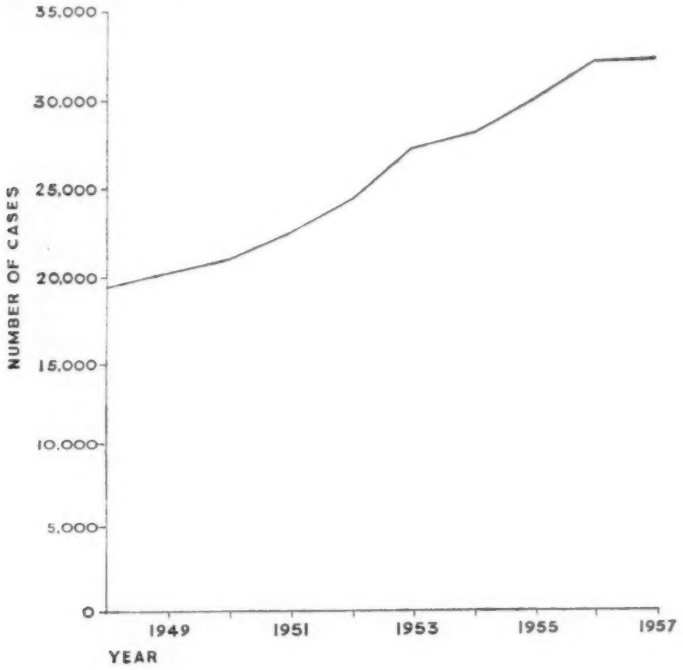


FIG. 3.—Notified cases of pulmonary tuberculosis on clinic registers.

The continuing increase from 1951 to 1957 is undoubtedly due to the improved survival of tuberculous patients arising from new methods of treatment. The statutory follow-up period for new cases is 5 years from attaining quiescence, and in many cases it is necessary to continue supervision for even longer.

PATIENTS WITH POSITIVE SPUTUM.—The number of patients on the registers at the end of each year known to have had positive sputum during the preceding 6 months (1 year as from December 31, 1955) is shown in Fig. 4.

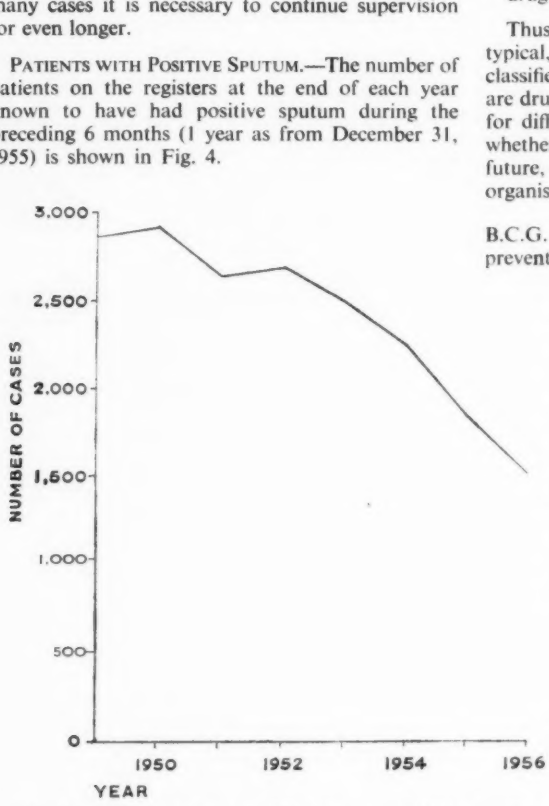


FIG.—Number of cases on clinic registers with positive sputum (during preceding 6 months).

A dramatic decrease has taken place since 1952; at the end of 1956 the total number of such patients was half that for the peak year 1950.

It is of interest to follow up such patients to find out the numbers still infectious after a given lapse of time. Such studies have not been made on a regional basis, but the following details have been supplied by Dr. J. Aspin, consultant chest physician at Wolverhampton (pop. 150,000).

"Of 282 patients infectious in 1955, 41 were alive and sputum positive in 1957, 192 being non-infectious after treatment, 42 dead, and seven lost sight of. Of the 41 cases still sputum positive in 1957, 26 were producing bacilli resistant to one or more of the major anti-tuberculous drugs, while fifteen were still producing fully-sensitive organisms. Of these 41 infectious cases, three were known to be at work and two of these were in the drug-resistant group."

Thus, if the experience in Wolverhampton is typical, 14 per cent. of infectious patients remain so classified 2 years later and almost two-thirds of these are drug-resistant. Different results may be obtained for different years, and it is important to find out whether these proportions are likely to change in the future, especially the proportion with drug-resistant organisms.

B.C.G. VACCINATION.—An important aspect of the preventive measures against pulmonary tuberculosis is the B.C.G. programme. It is the policy of all local authorities in the Region to vaccinate contacts, and all authorities except two have begun the vaccination of school-leavers. In the thirteen areas with schemes operating, the percentage of children for whom skin testing and vaccination is accepted varies between 41 and 93 per cent. Most authorities with an established programme obtained an acceptance rate of at least 70 per cent. in 1957. The proportion of those tested who were negative and vaccinated during 1957 varied between 36 and 86 per cent., and in most areas the proportion was about 80 per cent.

## OUT-PATIENT SERVICES

CHEST CLINIC ATTENDANCES.—Table IV shows that between 1949 and 1953 the number of new patients seen annually at the chest clinics more than doubled from 20,861 to 43,860; since 1953 the number of new attendances has fluctuated somewhat below the 1953 peak. The pattern for re-attendance

TABLE IV

CHEST CLINIC ATTENDANCES IN THE BIRMINGHAM REGION (1949–58)

| Year | Out-patient Attendances | | |
|---|---|---|---|
| | First Attendances | Re-attendances | Total |
| 1949 | 20,861 | 122,011 | 142,872 |
| 1950 | 29,982 | 103,603 | 133,585 |
| 1951 | 33,543 | 110,262 | 143,805 |
| 1952 | 37,679 | 135,333 | 173,012 |
| 1953 | 43,860 | 167,319 | 211,179 |
| 1954 | 41,075 | 172,455 | 213,530 |
| 1955 | 35,919 | 168,350 | 204,269 |
| 1956 | 39,918 | 171,606 | 211,524 |
| 1957 | 39,859 | 153,035 | 192,894 |
| 1958 | 38,295 | 145,666 | 183,961 |

is rather similar, with an increase from 122,011 in 1949 to a maximum of 172,455 in 1954, and numbers well below this level in 1957 and 1958.

Fig. 5 shows the total attendances at chest clinics each year, with a substantial increase between 1949 and 1954 and very little decline since. These figures are for all attendances and include contact and other routine examinations and attendances for refills. Detailed breakdown by categories is not available.

The number of new patients attending general medical out-patient clinics (including the teaching hospitals) in the Region was 57,000 a year for the years 1953–57. The total attendances (new and old) of medical out-patients was 205,000 a year over the same period, virtually the same total as for chest clinics.

In 1948 facilities for chest *x*-ray examination at the request of a general practitioner were rare or non-existent. Such services are now available throughout the Region, in some areas at the chest clinic or *x*-ray department of a hospital, in others at regular sessions by a mobile mass radiography unit, and in the City of Birmingham at a static mass radiography unit.

MASS RADIOGRAPHY SERVICE.—Table V and Fig. 5 show, as for clinic attendances, a progressive increase

TABLE V

MASS RADIOGRAPHY EXAMINATIONS IN THE BIRMINGHAM REGION (1949–57)

| Year | No. of Persons Examined | Cases of Active Tuberculosis* | Prevalence per 1,000 Examined |
|---|---|---|---|
| 1949 | 110,532 | 385 | 3·5 |
| 1950 | 98,412 | 502 | 5·1 |
| 1951 | 113,319 | 621 | 5·5 |
| 1952 | 195,677 | 1,125 | 5·7 |
| 1953 | 323,319 | 1,387 | 4·3 |
| 1954 | 395,327 | 1,357 | 3·4 |
| 1955 | 366,126 | 1,229 | 3·4 |
| 1956 | 351,314 | 1,220 | 3·5 |
| 1957 | 355,342 | 1,116 | 3·1 |

* Requiring immediate treatment or close supervision at a hospital or clinic.

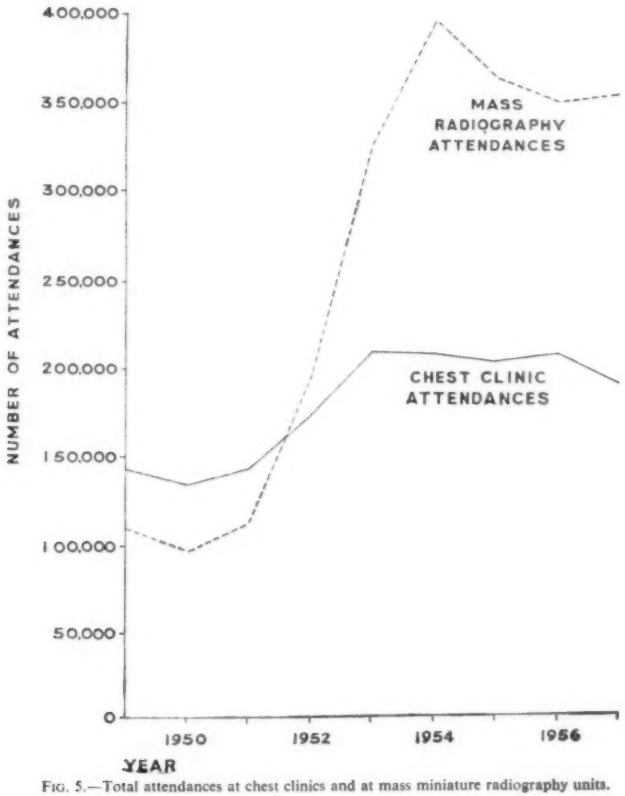


FIG. 5.—Total attendances at chest clinics and at mass miniature radiography units.

in the annual number of mass radiography examinations from about 100,000 in 1949 to just under 400,000 in 1954, after which the figure settles at just over 350,000. The yield of cases per 1,000 examined also increased at first, from 3·5 per 1,000 in 1949 to 5·7 per 1,000 in 1952, with a subsequent decline to 3·1 per 1,000 in 1957. Some of the increased yield in the earlier years was due to increasing proportions of high-yield groups such as general practitioner referrals. The subsequent decline must almost certainly represent a true decline in the prevalence of tuberculosis in the population, since the proportion of high-yield groups has been maintained.

## Out-Patient Treatment

Refills.—The number of refills performed at the Birmingham Chest Clinic each year is shown in Table VI. The increase in the first 5 years may be local to Birmingham and related to changes in medical staff; the steady decline since 1953 is presumably representative of the Region as a whole, though the decline was possibly more rapid in some areas.

Table VI
REFILLS AT BIRMINGHAM CHEST CLINIC

| Year | Number of Cases |
|---|---|
| 1948 | 5,000 |
| 1949 | 5,250 |
| 1950 | 6,000 |
| 1951 | 7,850 |
| 1952 | 11,500 |
| 1953 | 14,040 |
| 1954 | 12,000 |
| 1955 | 10,080 |
| 1956 | 6,240 |
| 1957 | 2,412 |
| 1958 | 512 |

Domiciliary Chemotherapy.—Although it has not been possible to obtain figures for the whole Region, it is known that in the county of Warwickshire visits by home nurses to tuberculous households declined steadily from 1954, and in Birmingham injections of streptomycin given to patients in their homes were reduced by two-thirds between 1955 and 1958 (Table VII). The decline occurred largely because, as the waiting time before admission to hospital was reduced, there was less need to give streptomycin by injection at home; a similar change would be shown by the rest of the Region as hospital admission became easier. Much chemotherapy is still continued at home after hospital treatment is completed, but the drugs are given mainly by mouth.

Table VII
VISITS BY NURSES TO PATIENTS' HOUSEHOLDS, 1953–1958

| Year | County of Warwickshire | City of Birmingham |
|---|---|---|
| | No. of Visits | No. of Injections of Streptomycin |
| 1953 | Not Available | 60,635 |
| 1954 | 21,755 | 62,156 |
| 1955 | 16,918 | 63,747 |
| 1956 | 12,077 | 56,586 |
| 1957 | 7,418 | 31,822 |
| 1958 | 4,955 | 20,381 |

Rehabilitation.—It is impossible to obtain figures which demonstrate the changes in return to work of patients treated for tuberculosis in the past 10 years. No figures are available on a Regional basis; in the City of Birmingham the number known to have been helped in return to suitable work rose steadily from 165 in 1948 to 574 in 1956, and declined only to 501 in 1957. This reflects the increasing number becoming fit for work as the result of treatment; it does not include those who return to their former work, and this group also is increasing. With regard to the type of work recommended, increasing numbers have been helped to return to normal industry, some after a period at the Industrial Rehabilitation Unit. The number undergoing training courses for new trades has been fairly constant at about fifty per year since 1951.

Entries to the special Remploy Factory for tuberculous patients numbered more than 100 per year in 1950–52, but have since declined to fifty per year; individuals working there are increasingly of a chronic type, some with positive sputum and unsuitable for return to open industry. Facilities of this kind are not available throughout the Region, and in some areas ambulant chronic patients provide a special problem.

## In-Patient Hospital Services

### Allocation and Occupation of Beds for Diseases of the Chest

Staffed allocated beds for the period 1948–57 are shown in Table VIII (opposite). An expansion programme started in 1948 added 533 beds, and by 1952 had increased the total to 2,825. There were only minor variations in subsequent years and generally these reflected limitations imposed by a shortage of nurses until 1958 when it was planned to reduce allocated beds by 631 within 3 years.

TABLE VIII

ALLOCATION AND OCCUPATION OF BEDS FOR DISEASES OF THE CHEST IN THE BIRMINGHAM REGION (1948–58)

| Year | Staffed Allocated Beds | Average Daily Number of Beds | | |
|---|---|---|---|---|
| | | Available | Occupied | Unoccupied |
| 1948 | 2,292 | — | — | — |
| 1949 | 2,555 | — | — | — |
| 1950 | 2,581 | — | — | — |
| 1951 | 2,753 | — | — | — |
| 1952 | 2,825 | — | — | — |
| 1953 | 2,780 | 2,745 | 2,585 | 160 |
| 1954 | 2,795 | 2,725 | 2,587 | 138 |
| 1955 | 2,821 | 2,767 | 2,539 | 228 |
| 1956 | 2,829 | 2,811 | 2,432 | 379 |
| 1957 | 2,799 | 2,796 | 2,239 | 557 |
| 1958 | 2,496 | 2,538 | 2,070 | 468 |

The medical waiting list in 1952 was 644; it is therefore probable that the "effective" bed occupancy was 100 per cent. The average daily number of staffed unoccupied beds for the Region was first collected in 1953, when the number was 160. There was an annual increase in this figure from 1954 and during 1957 there was an average of 557 staffed unoccupied beds each day.

RESPIRATORY TUBERCULOSIS

WAITING LISTS.—Detailed information of the size of the regional waiting list was not available until 1952, but it is probable that in the preceding quinquennium it had steadily swollen. The maximum known figure for medical and surgical cases combined was 978 in 1952. It fell by 13, 22, 43, 71 and 25 per cent. respectively, in subsequent years. The greatest percentage fall was between 1955 and 1956, and the greatest numerical fall was 279 between 1954 and 1955. On December 31, 1958, only 44 patients were awaiting admission.

Fig. 6 shows that until 1955 occupied beds plus waiting list exceeded the staffed available beds, but since 1956 staffed available beds have been adequate so that any case of pulmonary tuberculosis may now be admitted to hospital without delay.

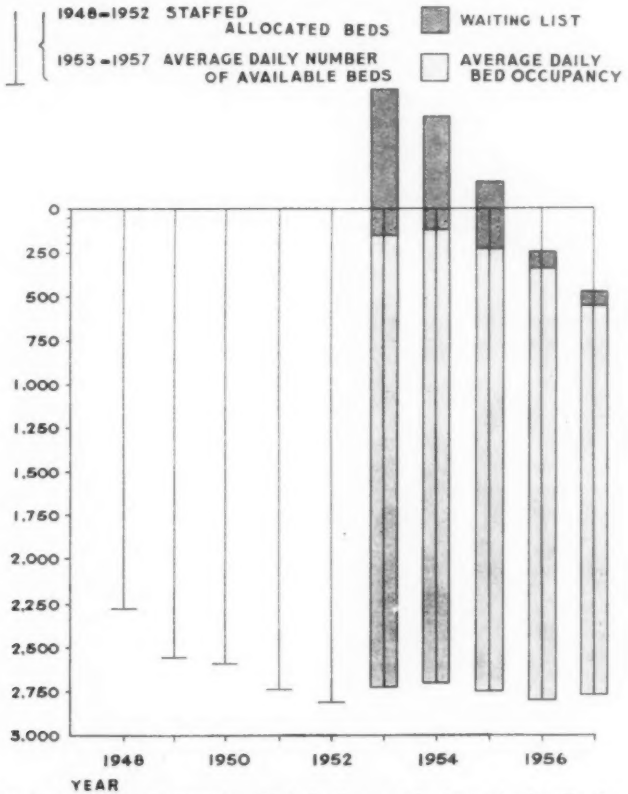


FIG. 6.—Availability and occupation of beds for diseases of the chest and waiting lists for respiratory tuberculosis.

HOSPITAL TREATMENT

(1) *Medical.*—The majority of pulmonary tuberculosis patients start treatment in hospital. The length of stay varies considerably between hospitals but the average in regional hospitals for patients who were discharged or died in 1957 was 150 days as compared with 171 days in 1949.

(2) *Surgical.*—The numbers of operations for pulmonary tuberculosis performed in the region are shown in Table IX. Surgical measures reached a peak in 1954. Thoracoplasty was painful, but safe and effective. Advances in anaesthesia enabled the development of resection, its safety being further enhanced by chemotherapeutic cover.

TABLE IX

SURGICAL TREATMENT, 1949–1957

| Year | Thoracoplasty | Resection | Total |
|---|---|---|---|
| 1949 | 389 | 14 | 403 |
| 1950 | 403 | 108 | 511 |
| 1951 | 642 | 147 | 789 |
| 1952 | 789 | 214 | 1,003 |
| 1953 | 870 | 300 | 1,170 |
| 1954 | 971 | 365 | 1,336 |
| 1955 | 812 | 375 | 1,187 |
| 1956 | 633 | 411 | 1,044 |
| 1957 | 382 | 265 | 647 |

SPECIAL TREATMENT UNITS.—Treatment in hospital of tuberculosis in certain classes of people presents special problems:

(1) *Children.*—The treatment of children necessitates many months in hospital and arrangements have to be made for their education. In the Birmingham Region three special units for children were developed, comprising in all 182 beds, in addition to children's units within several sanatoria.

(2) *Pregnancy.*—This posed difficult problems before the introduction of effective chemotherapy. Many pregnant patients with tuberculosis can now be managed without special facilities, but isolation accommodation for a limited number of infectious cases is necessary in maternity departments.

(3) *Diabetes.*—In patients with diabetes, tuberculosis may be extensive and at times difficult to cure. Diabetic patients need to learn the self-administration of insulin. A Regional unit of 25 beds for this type of case was established at Romsley Hill Hospital near Birmingham, but most patients in peripheral areas are treated in a general or chest hospital by the chest physician, often in collaboration with a general physician.

(4) *Patients in Mental and Mental Deficiency Hospitals.*—There is evidence of a higher tuberculosis morbidity rate in mental patients than in similar groups of normal persons. The period of treatment tends to be long, and the problems of discharge connected with the mental state are often difficult. Most mental hospitals provide isolation accommodation on a limited scale; in addition a unit of 69 beds for male patients has been developed at one mental hospital to which patients can be transferred. Similarly, a special unit of 81 beds for mental defectives was set up at one of the Birmingham mental deficiency hospitals for regional use.

DISCUSSION

The remarkable fall in tuberculosis mortality in the 10 years from 1948 has sometimes led to insufficient attention being paid to other yardsticks which may be of greater importance in planning future needs. Early in this report it was shown that the combination of rapidly declining mortality with an unchanging or slowly falling notification rate inevitably led to a substantial increase in the number of persons on the live tuberculosis register, all needing regular supervision. This in part explains the increase in the number of re-examinations at chest clinics, the other cause being the need for regular supervision at reasonably short intervals of patients who have started chemotherapy at home because of an insufficient number of beds in hospital. In the last 2 or 3 years, however, waiting lists have declined and disappeared, so that all patients who need it can now start their treatment in hospital. Regular review of bed requirements will be necessary in future, though it is essential from the public health aspect to ensure that an adequate number of beds for the prompt admission of all tuberculous patients is available.

From the epidemiological aspect the decline in the number of patients with positive sputum represents a real advance, though the proportion with resistant organisms is a feature which gives rise to anxiety. The greatly increased use of B.C.G. vaccination in the past 5 years should soon produce results by reducing the number of new cases in young adults, though this measure must be regarded as a long-term cumulative investment rather than as one which can produce rapid results.

The majority of new cases of tuberculosis are still identified through general practitioner referrals, either for "*x* ray only" or for normal consultative

sessions. The mass radiography service is, however, responsible for an appreciable number of new diagnoses which could be made in no other way at that stage of the disease; their work will need to continue on an undiminished scale, though it is to be hoped with a diminishing return, and the use of some units for intensive community surveys has been instituted. The increasing provision of "*x* ray only" sessions for general practitioners is probably responsible for the recent small decline in the number of new attendances at chest clinics.

On the hospital side the major change has been from enormous waiting lists to the existence of some empty beds and to a reduction in the number of beds allocated to tuberculosis. There has also been a great decline in the number of surgical operations for tuberculosis. It has often been difficult to find sufficient nursing staff for the available beds, and the very effectiveness of treatment has tended to increase this by tending to make the work less interesting because of its apparent simplicity, and also by reducing the number of ex-patients who have taken up nursing in sanatoria because they were not fit enough to return to their original work.

Whilst steady progress in anti-tuberculosis work is being made, the present situation of an infectious disease of which over 3,000 new cases are notified in the Region each year cannot be regarded as satisfactory. Other features which indicate that there is still much to be done are the absence of any fall in the number of deaths from tuberculosis of patients not previously notified, the number of patients sputum-positive with resistant organisms, and the fact that in 1957 at least 13 per cent. of children have been infected with tuberculosis by the age of 13 years. It has recently been said that tuberculosis will have been eliminated as a critical public health problem when no more than 1 per cent. are infected by the age of 14 years.

## Summary

(1) In the Birmingham Hospital Region, the mortality rate from pulmonary tuberculosis in men declined from 52 per 100,000 in 1948 to 17 in 1957; in women it declined from 29 to 4 per 100,000 in the same period.

(2) Notification rates for pulmonary tuberculosis in men declined from 125 per 100,000 in 1948 to 83 in 1957; in women they declined from 81 to 51 per 100,000 during the same period.

(3) As a result of rapidly declining mortality and slowly declining notifications, the numbers of persons on the respiratory tuberculosis registers in the Region have increased from 19,459 in 1948 to 31,828 in 1957. The number of these patients known to have had tubercle bacilli in their sputum in the previous 6 months declined from 2,875 in 1949 to 1,516 in 1956.

(4) At least half of all new notifications were made as a result of patients reporting symptoms to their general practitioners. The contact service and mass radiography (excluding general practitioner referrals) each contributed about 10 per cent. of all notifications.

(5) B.C.G. vaccination has been introduced into the Region in the past 10 years; it is extensively used for contacts, but its use among 13 to 14-year-old schoolchildren varies from nil in some areas to a more than 80 per cent. acceptance rate in other areas.

(6) Total attendances at chest clinics in the Region rose from 142,872 in 1949 to 213,530 in 1954 and have since remained at about 200,000 per annum; the pattern has been similar for first attendances and for re-examinations, but with a rather greater proportional increase in first examinations than in re-examinations.

(7) Examination by mass radiography units increased from 110,532 in 1949 to 395,327 in 1954 and thereafter continued at over 350,000 per annum. Increasing provision has been made for *x*-raying patients at the request of general practitioners.

(8) Artificial pneumothorax and pneumoperitoneum have virtually disappeared as methods of treatment, and the many thousands of refills previously done each year are now no longer needed. Domiciliary chemotherapy, including streptomycin injections in the home, reached a maximum in 1954–55; the use of streptomycin in the home has since declined very considerably.

(9) Staffed hospital beds allocated for the treatment of tuberculosis and diseases of the chest increased from 2,292 in 1948 to 2,829 in 1956, and were slightly reduced in 1957. There was a further substantial reduction in 1958.

(10) The waiting list for admission to hospital for treatment of tuberculosis totalled 978 in 1952 (the earliest year for which the figure is available). The waiting lists subsequently declined substantially, and at the end of 1958 only 44 patients were awaiting admission; considerably more than this number of staffed allocated beds were then unoccupied.

(11) Major surgical operations for the treatment of pulmonary tuberculosis increased from 403 in 1949 to 1,336 in 1954, and then declined to 647 in 1957.

*Brit. J. prev. soc. Med.* (1959), **13**, 204–210

# THE GEOGRAPHICAL DISTRIBUTION OF DISEASE WITH SPECIAL REFERENCE TO CANCER OF THE LUNG AND STOMACH IN WALES

BY

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The geographer in his work relies extensively on maps and in this respect there would seem to be a useful field for joint exploration between geographer, human ecologist, epidemiologist, and medical statistician. The mapping of statistical data is now generally accepted to be the method of attacking many problems in biology, geology, geography, meteorology, climatology, economics, administration, etc., and its obvious importance in the understanding of areal relationships of diseases is such that it is somewhat surprising that more is not being done by the medical profession. The comparison of endemic areas with areas free from the disease may well throw valuable sidelights on causation. Once the active cause and the predisposing associations of a disease are defined, the path is opened to sound preventive measure. If the cause is unknown the difficult early stages of the problem may well be clarified by a map showing the geographical variations of the particular disease. The deeper causes of the distribution can then be studied and it may well be that the distributional patterns displayed are paralleled by those of some other known phenomenon. These, in their turn, may give a clue to causation. This is not to suggest that problems are elucidated merely by mapping broad areal relationships. Rather, it is thought that useful pointers and relationships might well emerge from such an exercise.

The "World Atlas of Epidemic Diseases" (Rodenwaldt, 1954ff.) and the series of maps prepared by May (1950 ff.) for the American Geographical Society are especially valuable for those interested in the environmental conditions of global disease. Learmouth (1954) gives a useful example of how to convey much information in a single map, and has demonstrated the geographical treatment of 20 years' medical statistics for the former British India (Learmouth, 1958). Audy (1958) employs cartographic and graphical techniques to demonstrate the usefulness to the epidemiologist of the synoptic view given by the map. Stocks (1936, 1937, 1939) has frequently adopted cartographic techniques to represent medical statistics, and in 1936 used maps of England and Wales showing standardized mortality of cancer to demonstrate marked contrasts between high incidence in the mountainous areas of Wales and parts of the north of England, and low incidence in the chalk areas of the south-east of England. Subsequent workers were thus able to concentrate their efforts more definitely in the areas of heaviest mortality. Two maps (Figs. 1 and 2) are presented here to illustrate the kind of detailed choropleth (quantity in area) map that can be constructed from mortality data given in the Medical Tables and Text Volumes of the Annual Statistical Reviews of the Registrar General.

## Construction of Maps

Malignant disease is selected for study, and the intention is to show the geographical incidence in Wales of mortality from cancer of the lung and bronchus in males, and cancer of the stomach in females during the 7-year period, 1947–53. This period provided a large enough sample of mortality data and it had the advantage that in 1951 a population census took place which enabled accurate calculations. Standardized mortality ratios (S.M.R.) were calculated to obviate fallacious comparisons of crude death rates and to give due allowance for sex-age differences in the population and for degree of urbanization. Deaths from cancer of the lung-bronchus and of the stomach for the period 1947–53 were obtained from the appropriate Statistical Reviews* for the County Boroughs of Wales, and for the urban and rural districts of each Welsh

* These statistics are based on death certificates. Cause of death is not always certain and in the absence of proof by autopsy the complete reliability of these data may be in doubt.

county, including Monmouthshire (Registrar General, 1956). Ratios of deaths from cancer of these organs in England and Wales in the years 1947–53 to the 1951 census populations at six age groups (0–34, 35–44, 45–54, 55–64, 65–74, 75 and over) for each sex were multiplied by the corresponding local census populations and the resulting products aggregated to give "expected" deaths. The actual deaths for 1947–53 were then expressed as percentage ratios of the "expected" totals to give standardized mortality ratios. The standardized mortality ratio is expressed in terms of the standard England and Wales rates taken as 100 in every case. If the S.M.R. of a particular area is 100 it means that this area experienced in the 7 years of study a mortality equal to that for England and Wales as a whole; if the S.M.R. is 200 the rate is twice as great as the national average.

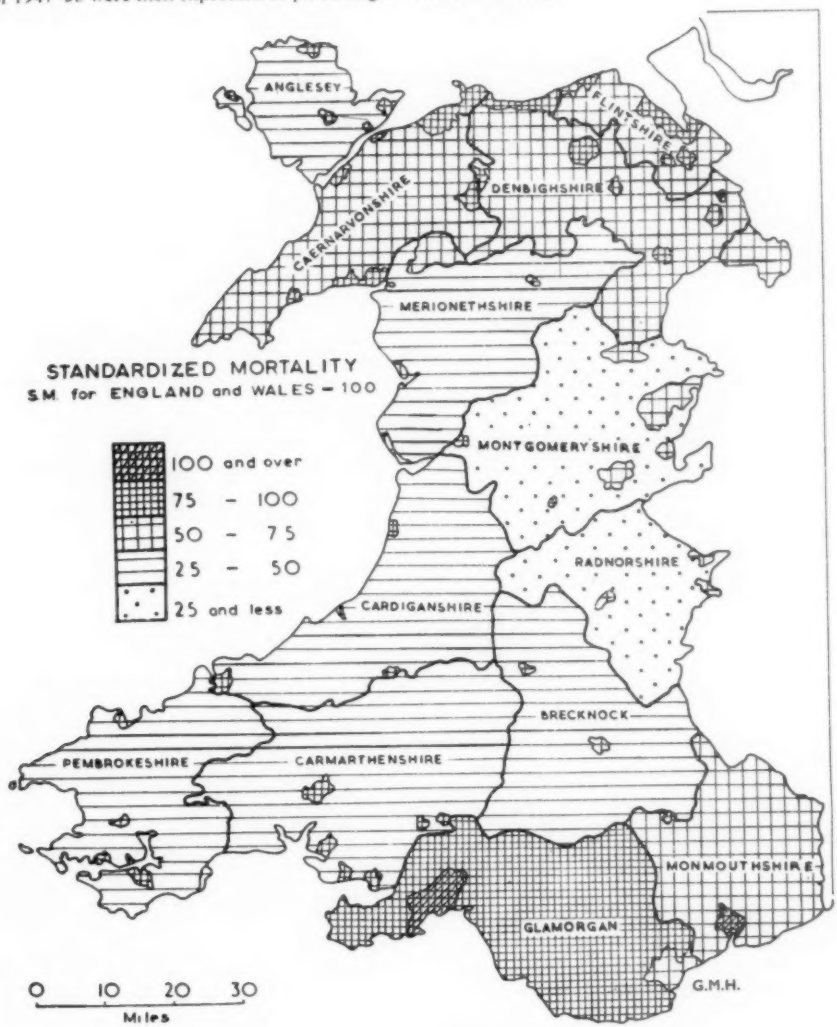


FIG. 1.—Cancer of Lung and Bronchus, standardized mortality for males, 1947–53.

It is necessary to exercise care in choosing interval values for the standardized mortality ratios to be displayed on a map. Ideally a "dispersion diagram" should be prepared to ensure full weight for the major standardized mortality values and for important variations. This has been done for Figs 1 and 2, which, consequently, have different keys.

Computations of S.M.R. have been made on the basis of data available in the Statistical Reviews, and the lines on the map represent county boundaries or the boundaries of county boroughs, urban districts, or rural districts. Where values in adjacent districts correspond there has been grouping, and the administrative boundary has been omitted. It must not be assumed that the mortality rates depicted necessarily prevail over the whole of a particular administrative district whether it be urban, rural, or a county borough. All that can

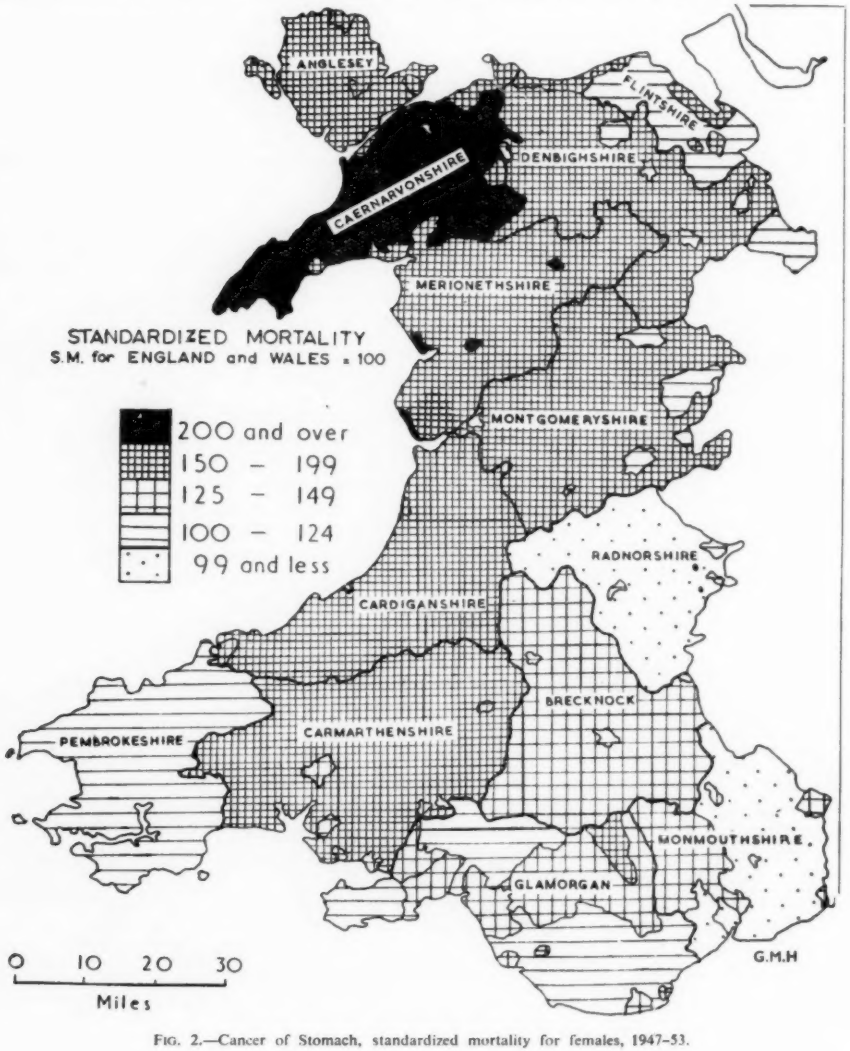


FIG. 2.—Cancer of Stomach, standardized mortality for females, 1947–53.

reasonably be assumed is that the mortality rates so displayed are those which prevail among a large proportion of the populations resident in the counties or parts of the counties mapped. Regions of specific cancer mortality rates must exist in the general areas enclosed by the administrative boundary lines but they are unlikely to be co-extensive with them.

### Features of the Distribution of Cancer Mortality revealed by the Maps

Maps of crude aggregates of cancer deaths in Wales would merely reflect the distribution of population which is characterized by an overwhelming dominance of two zones of dense population associated with the industrial areas in North-East Wales and South Wales respectively and a central zone of sparse population associated with the mountainous heartland of the principality (Fig. 3).

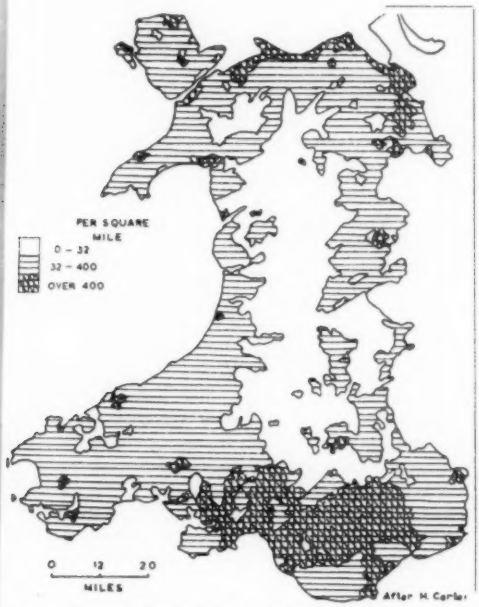


Fig. 3.—Density of population in Wales, 1951 (after H. Carter).

Even so Fig. 1, which is based on S.M.R.s, does bear a resemblance to the distributional pattern revealed in Fig. 3. On the other hand, the pattern shown in Fig. 2 is quite different and reveals a rural distribution.

Welsh rates for cancer of the lung and bronchus for men (Fig. 1) are below the national average for England and Wales, except in Swansea County Borough, where deaths totalled 360 compared with the expected 277 (S.M.R.130), and in Newport County Borough with 193 deaths compared with 170 expected (S.M.R. 105). In every county except Glamorgan, the S.M.R.s for the urban districts are slightly in excess of those for the rural districts. In Glamorgan the S.M.R. for Cardiff County Borough is 58, for Merthyr Tydfil County Borough 81, for Swansea County Borough 130; all other urban Districts 77; rural districts 79.

Cancer of the stomach for females in Wales is such that rural Caernarvonshire and the small urban areas of Merionethshire have ratios more than twice as high as expected (S.M.R.s 243 and 220 respectively). In rural Monmouthshire and Radnorshire there is no excess over the national average. Pembrokeshire, rural Glamorgan, rural Flintshire, and the small urban areas of Montgomershire have indices between 100 and 124; in the remainder of Wales the mortality ratios range from $1\frac{3}{4}$ times to twice the national average.

### Discussion

From the contrasting distributional patterns shown in Figs 1 and 2, it seems reasonable to infer that the causal factors differ in each case. The higher ratios for lung and bronchus (Fig. 1) in the more densely populated areas (Fig. 3)—though generally below the England and Wales average—suggest some parallel between the two. This is not to invoke a straightforward causal relationship but rather to reflect that the greater the degree of crowding together of people in industrial communities the greater is the atmospheric pollution resulting from the increased numbers of domestic and industrial chimneys, or from fumes from factories and motor vehicles. In addition there is a greater danger of food contamination from pollution-ridden atmosphere and a greater risk of infections (Boyland, 1958; Stocks, 1959a)—factors which are thought to have an association with cancer of the lung. Not that all the smoke and other pollution generated in an urban industrial area necessarily remains there. In average windy weather about half is blown away. Since the prevailing winds in Wales blow from the west and south-west (see wind roses for Holyhead and St. Ann's Head in Fig. 4, overleaf), the smoke, soot particles, and chemical gases from industrial South and North-East Wales are spread away to the east-north-east, thereby considerably reducing the "country pollution" within Wales itself.

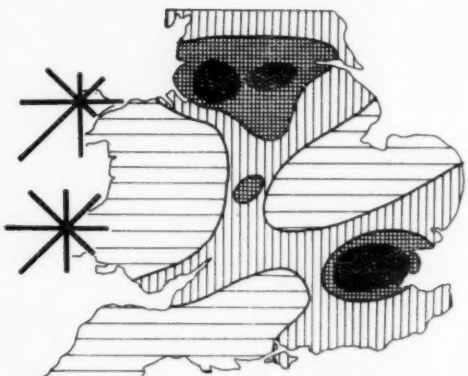


FIG. 4.—Country pollution, based on deposits in pollution gauges (after C. E. P. Brooks).

Fig. 4, adapted from Brooks (1954) reveals that, on the basis of deposits in pollution gauges (values in tons per square kilometre per annum), even the industrial North-East and South Wales are remarkably free from pollution, despite the greater consumption of coal in private houses and factories in these areas compared with the rest of Wales (Fig. 5).

Nevertheless the suggestion that there is "an inverse relationship between hours of sunshine and cancer of the lung" (Roberts and Shaw, 1958) does not appear to be borne out by a comparison of Fig. 1 and Fig. 6.

Stomach cancer (Fig. 2) on the other hand seems to be unrelated to urbanization. On the contrary a rural distribution is illustrated in which some other geographical association, not necessarily social or human, may play a part. Stocks (1959b), Davies and Griffiths (1954) and Legon (1952) have provided evidence for North Wales which suggests a relationship between heavy mortality rates from stomach cancer and soils with high organic content and bad drainage. It is thought that stomach cancer mortality may be "conditioned by micronutrient deficiencies in food plants grown on soils of high organic content". Further, it is suggested that populations whose diets include vegetable foods grown on such soils may be subjected to the action of carcinogens or may be deprived of protective substances". If such a relationship really exists, is not the role of vegetable foods*

* 78–85 per cent. of the vegetables are brought into North Wales, except in the case of potatoes where the consumption of local-grown crops would be high.

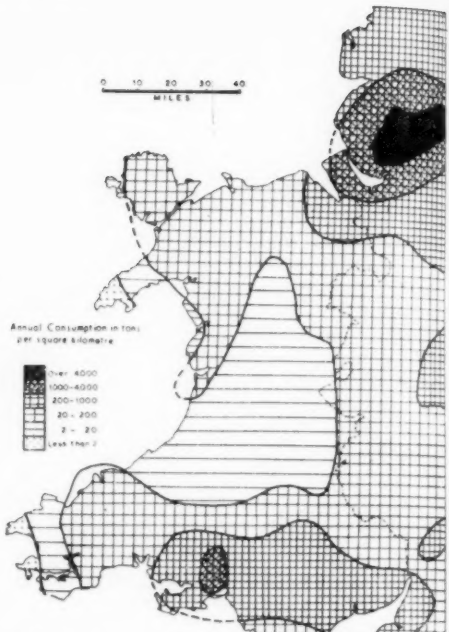


FIG. 5.—Consumption of coal (after C. E. P. Brooks).

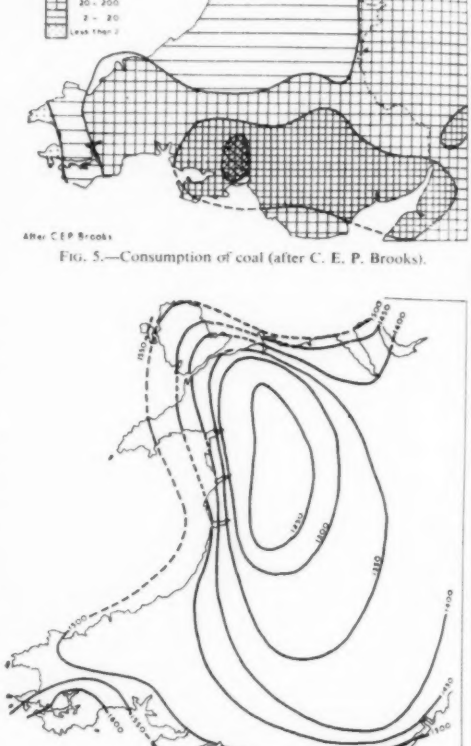

FIG. 6.—Distribution of bright sunshine in Wales, 1921–50 (based on M.O.572).

over-emphasized? It is far more likely that a medium in constant and daily use other than vegetable food is conveying the carcinogens from the ground or soil to the body. Drinking water seems an obvious vehicle since it is affected by the strata and soil over which and through which it flows. In Wales the surface rocks are, on the whole, stable and insoluble, and the underground water supply is comparatively small (North, 1936). Surface water supplies therefore acquire their characteristics either from the atmosphere or from the prevailing soil type. Vast expanses of the water catchment area of upland Wales are covered with hill peats, and it has been estimated that more than half of the soils in Wales suffer from some degree of drainage impedance—presumably more so in the wetter north and west than in the drier south and east (Robinson and Roberts, 1936). Acidity and organic matter is transferred from the peat soils to the water flowing through them, while bad drainage and water logging inevitably leads to water stagnation and pollution. In such cases one is dealing with the circumstances, *viz.* high organic content and the effects of bad drainage, thought by many workers to be related to high incidence of mortality from cancer of the stomach (Stocks, 1959c; Davies and Griffiths, 1954; Legon, 1952; Tromp, 1956).

Fig. 7, based on the "Water Engineer's Handbook" (1958), is included to show that the *treated* water supplied by the majority of the water undertakings in Wales is characterized by an overall deficiency in the sulphates and chlorides of calcium and/or magnesium. The same would seem to apply to farms not in receipt of piped water from public supplies. Of 4,250 farm water supplies examined by bacteriologists of the National Agricultural Advisory Service during the period 1953–58, 72 per cent. were found to be in the soft or moderately soft category and only 7 per cent. hard or excessively hard (Thomas, 1959). In the case of the piped water supplies of the various Welsh undertakings, undesirable characteristics like acidity, organic material, and aquatic organisms (minute crustacea, water fleas, cyclops) will have been removed by sterilization, filtration, chlorination, and general purification. The unpiped water available to much of the rural population receives no such purification.

The proportion of the rural population of Wales that is without piped water is appreciable. The "National Farm Survey of England and Wales" (Ministry of Agriculture and Fisheries, 1946) disclosed that, apart from Glamorgan, Monmouthshire, and Flintshire, over 55 per cent. of the farm holdings in Wales were without a piped water supply. Many of those holdings reporting "piped

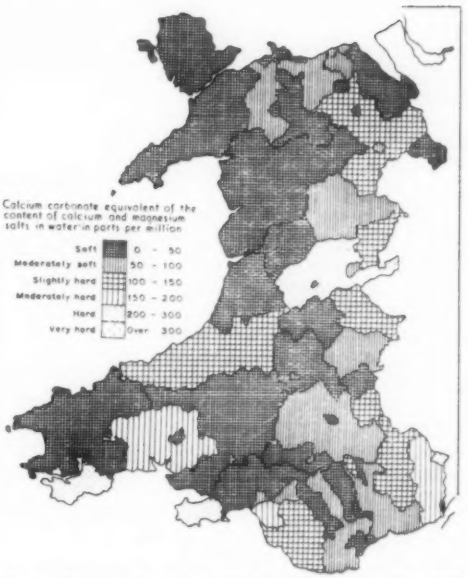
Calcium carbonate equivalent of the content of calcium and magnesium salts in water in parts per million
Soft 0 - 50
Moderately soft 50 - 100
Slightly hard 100 - 150
Moderately hard 150 - 200
Hard 200 - 300
Very hard Over 300

FIG. 7.—Character of water supplied to Welsh consumers, 1958 (from Water Engineer's Handbook).

water supply" received their water, not from public water undertakings, but from local sources like springs, shallow wells, streams, impounded rivers, and lakes, all of which are liable to surface pollution, especially contamination from human and animal sources. The proportion of the rural population receiving untreated water is thus higher than 55 per cent. of the holdings would suggest. In addition, over 20% of the farm holdings in Wales (except Flintshire) experience a seasonal shortage, at which times an already doubtful water supply is made even more questionable.

It is not without significance that, of the 12,863 Welsh farm water supplies examined by N.A.A.S. bacteriologists during the past 9 years (1949–58), only 6,308 supplies (49 per cent.) were classed as acceptable for dairy purposes on field observation and bacteriological examination. Of these 6,308 supplies, 51 per cent. required very little further protective work, 35 per cent. required extensive improvements, and the remaining 14 per cent., although protected as far as was practicable, could only be accepted as suitable provided that the water was boiled or treated with a suitable quantity of hypochlorite (Thomas, 1959). In the course of years the irritant and other effects of drinking water with undesirable constituents may well be appreciable

and one wonders if the polluted and untreated waters used by much of the rural population in Wales—where the incidence of stomach cancer is known to be high (Fig. 2)—might not be worthy of detailed examination in relation to stomach cancer?

## Conclusions

It is not intended that the foregoing considerations, illustrated by reference to lung and stomach cancer in Wales, be considered an original contribution to knowledge of cancer causation, but it is hoped to suggest that the mapping of diseases to show areal relationships may help to clarify general situations in the difficult early stages of certain medical problems. The regional confinement of many diseases may well parallel aggregations of population or the secondary effects associated with such aggregations, such as atmospheric pollution, sanitation, etc., or with such factors as marital state, blood groups, diets, climatic factors, soils, or water supplies, most of which can be depicted in map form. In the mapping of these and like phenomena the geographer can claim some expertise, and this, together with his sense of regional variation, should make him a useful collaborator in many medical research projects.

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*Brit. J. prev. soc. Med.* (1959), 13, 211–214

# BRONCHITIS IN THE INSURED POPULATION OF NORTHERN IRELAND

BY

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Oswald (1958) raises a doubt whether bronchitis is an English disease or an English diagnosis. This emphasizes the fact that most of the present knowledge of this and other chronic diseases is derived from mortality statistics and judged on this basis bronchitis ranks extremely high in the United Kingdom. England and Wales head the list, with Northern Ireland second, followed by Scotland and Spain; Denmark occupies the lowest place. It is difficult to explain why the recorded mortality rates in the other European countries, Canada, and the United States should be so much lower. Christensen and Wood (1958), after examining the variables, including diagnostic habits in both countries, conclude that there is a real excess of the disease labelled bronchitis in England and Wales as compared with Denmark.

It is clear that morbidity data on bronchitis, from whatever source it may be derived, should give a better picture of the incidence of the disease and its incapacitating effect on the population. Several valuable *ad hoc* studies have been carried out, of which recent notable contributions are from Newcastle-upon-Tyne (Ogilvie and Newell, 1957) and Salford (Hughes, 1957).

Stuart-Harris (1954) has shown that it is possible to use the analyses derived from national insurance data as a basis for estimating the size of the problem. Digests of statistics analysing certificates of incapacity are issued annually by the Ministry of Pensions and National Insurance and show, under fifty main diagnostic headings, the causes of incapacity for work for virtually the entire working population of Great Britain, including both employed and self-employed persons. This information is based on doctors' certificates issue d for purpose of sickness benefit.

Separate and similar analyses are carried out in Northern Ireland by the Ministry of Labour and National Insurance with a much smaller population at risk. Using this data, Park and Kidd (1958), in a general study on morbidity in the insured population in Northern Ireland, have shown that in terms of the duration of spells of incapacity bronchitis takes a high place and has a longer median duration than that experienced in Scotland.

Having full regard to the limitations of morbidity studies derived from national insurance sources, it was still felt worthwhile to record further statistical data of this widespread disease.

Information was available on a 20 per cent. sample basis for the three complete years ending May 31, 1955, 1956, and 1957, in the form of new spells commencing each year, the duration of spells completed each year, and the number of spells lasting more than one year. The diagnoses were coded according to the Abridged List of the International Statistical Classification of Diseases.

Morbidity was heaviest in the middle year under review and this was reflected in the bronchitis figures. For men the only diagnostic groups with inception rates higher than bronchitis were influenza, diseases of the stomach, arthritis, and accidents. For married women, the complications of pregnancy, childbirth, and puerperium, anaemia, and arthritis and for other women anaemia, influenza, and tonsillitis had higher inception rates.

Table I (overleaf) shows that the inception rate for bronchitis is about one and a half times higher for married women than for men, whereas for other

TABLE I

NUMBER OF NEW SPELLS OF INCAPACITY AND INCEPTION RATES FOR BRONCHITIS; SHOWING NUMBER OF SPELLS OF SICKNESS PER 1,000 EXPOSED TO RISK, BY AGE AND SEX (20 PER CENT. SAMPLE)

| Sex | | Age Group (yrs) | 1954–55 | | 1955–56 | | 1956–57 | |
|---|---|---|---|---|---|---|---|---|
| | | | No. of Spells | Inception Rates | No. of Spells | Inception Rates | No. of Spells | Inception Rates |
| Men | | 15–19 | 112 | 15·8 | 106 | 14·9 | 104 | 14·4 |
| | | 20–29 | 159 | 11·4 | 167 | 12·0 | 183 | 13·2 |
| | | 30–39 | 206 | 14·1 | 254 | 17·4 | 231 | 15·7 |
| | | 40–49 | 329 | 22·4 | 343 | 23·3 | 367 | 24·8 |
| | | 50–59 | 450 | 36·0 | 488 | 39·0 | 419 | 33·5 |
| | | 60–64 | 161 | 35·0 | 234 | 50·9 | 191 | 35·7 |
| | | Total | 1,417 | 21·0 | 1,592 | 23·6 | 1,495 | 22·0 |
| Women | Married | 15–19 | 8 | — | 6 | — | 6 | — |
| | | 20–29 | 65 | 26·0 | 78 | 31·2 | 70 | 25·0 |
| | | 30–39 | 66 | 34·7 | 76 | 40·0 | 62 | 36·4 |
| | | 40–49 | 78 | 39·0 | 75 | 37·5 | 64 | 33·7 |
| | | 50–59 | 50 | 35·7 | 70 | 50·0 | 56 | 40·0 |
| | | 60–64 | — | — | — | — | — | — |
| | | Total | 267 | 33·3 | 305 | 38·1 | 258 | 32·3 |
| | Other | 15–19 | 129 | 17·7 | 119 | 16·3 | 126 | 17·0 |
| | | 20–29 | 144 | 19·0 | 139 | 18·3 | 139 | 18·5 |
| | | 30–39 | 39 | 13·0 | 76 | 25·3 | 49 | 16·3 |
| | | 40–49 | 44 | 16·9 | 59 | 22·7 | 56 | 21·5 |
| | | 50–59 | 58 | 20·7 | 61 | 21·8 | 63 | 22·5 |
| | | 60–64 | — | — | — | — | — | — |
| | | Total | 414 | 17·8 | 454 | 19·5 | 433 | 18·6 |

TABLE II

RATIOS OF INCEPTION RATES FOR BRONCHITIS FOR THE THREE SEX-MARITAL GROUPS, BY AGE

| Age Group (yrs) | 1954–55 | | | 1955–56 | | | 1956–57 | | |
|---|---|---|---|---|---|---|---|---|---|
| | M.W. / M | O.W. / M | M.W. / O.W. | M.W. / M | O.W. / M | M.W. / O.W. | M.W. / M | O.W. / M | M.W. / O.W. |
| 15–19 | — | 1·1 | — | — | 1·1 | — | — | 1·2 | — |
| 20–29 | 2·3 | 1·7 | 1·4 | 2·6 | 1·5 | 1·7 | 2·3 | 1·4 | 1·4 |
| 30–39 | 2·5 | 0·9 | 2·7 | 2·3 | 1·5 | 1·6 | 2·3 | 1·0 | 2·2 |
| 40–49 | 1·7 | 0·8 | 2·3 | 1·6 | 1·0 | 1·7 | 1·4 | 0·9 | 1·6 |
| 50–59 | 1·0 | 0·6 | 1·7 | 1·3 | 0·6 | 2·3 | 1·2 | 0·7 | 1·8 |
| All Ages | 1·6 | 0·8 | 1·7 | 1·6 | 0·8 | 2·0 | 1·5 | 0·8 | 1·7 |

women it is lower than for men. After age 20 male inception rates increase steadily with age; for women there is a slight increase with age, but this is by no means consistent. The ratios of inception rates for the three sex-marital groups shown in Table II demonstrate some interesting points. Why, for example, should young married women have so much more bronchitis than the other two groups?

Table III (opposite) shows that the duration of spells of incapacity for married women are on the average longer than for men and for other women. In 1956–57, 38 per cent. of the spells for married women lasted less than 3 weeks; the corresponding figure for men was 44 per cent. and for other women 54 per cent.

Table IV (opposite) shows the number of spells of bronchitis which caused the patient to be incapacitated for more than one year; from the known age distribution of the three groups it is clear that the incidence of long-term bronchitis increases with age. It is difficult to draw conclusions from this Table as the actual numbers in the sample are small, but married women seem to have, overall, a worse experience than the other two groups and this is supported by the age-specific rates. There are, in fact, relatively more married women than men in this category and only about one per 1,000 other women are incapacitated for more than one year. In males there is an appreciable increase in long-term bronchitic illness from about age 50.

TABLE III

DURATION OF COMPLETED SPELLS FOR BRONCHITIS, BY SEX (20 PER CENT. SAMPLE)

| Sex | | Duration (days) | 1954–55 | | | 1955–56 | | | 1956–57 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | No. of Spells | Percentage | Cumulative Percentage | No. of Spells | Percentage | Cumulative Percentage | No. of Spells | Percentage | Cumulative Percentage |
| Men | | 1–3 | 16 | 1·1 | — | 35 | 2·2 | — | 16 | 1·0 | — |
| | | 4–6 | 131 | 9·0 | 10·1 | 142 | 9·1 | 11·3 | 161 | 10·4 | 11·4 |
| | | 7–12 | 283 | 19·5 | 29·6 | 270 | 17·2 | 28·5 | 258 | 16·7 | 28·1 |
| | | 13–18 | 256 | 17·7 | 47·3 | 261 | 16·6 | 45·1 | 249 | 16·1 | 44·2 |
| | | 19–24 | 169 | 11·7 | 59·0 | 162 | 10·3 | 55·4 | 167 | 10·8 | 55·0 |
| | | 25–48 | 296 | 20·4 | 79·4 | 360 | 22·9 | 78·3 | 339 | 22·0 | 77·0 |
| | | 49–78 | 136 | 9·4 | 88·8 | 147 | 9·4 | 87·8 | 137 | 8·9 | 85·9 |
| | | 59–156 | 82 | 5·6 | 94·4 | 110 | 7·0 | 94·7 | 107 | 6·9 | 92·8 |
| | | 157–312 | 39 | 2·7 | 97·1 | 34 | 2·2 | 96·9 | 50 | 3·2 | 96·0 |
| | | 312+ | 42 | 2·9 | 100·0 | 49 | 3·1 | 100·0 | 61 | 4·0 | 100·0 |
| | | Total | 1,450 | 100·0 | — | 1,570 | 100·0 | — | 1,545 | 100·0 | — |
| Women | Married | 1–3 | 2 | ·8 | — | 3 | 1·0 | — | 3 | 1·1 | — |
| | | 4–6 | 19 | 7·5 | 8·3 | 18 | 6·1 | 7·1 | 21 | 7·7 | 8·8 |
| | | 7–12 | 33 | 13·1 | 21·4 | 55 | 18·6 | 25·7 | 39 | 14·2 | 23·0 |
| | | 13–18 | 48 | 19·1 | 40·5 | 54 | 18·3 | 44·0 | 42 | 15·3 | 38·3 |
| | | 19–24 | 33 | 13·1 | 53·6 | 25 | 8·5 | 52·5 | 27 | 9·9 | 48·2 |
| | | 25–48 | 57 | 22·6 | 76·2 | 67 | 22·7 | 75·2 | 66 | 24·1 | 72·3 |
| | | 49–78 | 24 | 9·5 | 85·7 | 27 | 9·2 | 84·4 | 26 | 9·5 | 81·8 |
| | | 69–156 | 18 | 7·1 | 92·8 | 24 | 8·1 | 92·5 | 26 | 9·5 | 91·3 |
| | | 157–312 | 10 | 4·0 | 96·8 | 12 | 4·1 | 96·6 | 13 | 4·7 | 96·0 |
| | | 312+ | 8 | 3·2 | 100·0 | 10 | 3·4 | 100·0 | 11 | 4·0 | 100·0 |
| | | Total | 252 | 100·0 | — | 295 | 100·0 | — | 274 | 100·0 | — |
| | Other | 1–3 | 1 | ·2 | — | 4 | ·9 | — | — | — | — |
| | | 4–6 | 38 | 9·1 | 9·3 | 38 | 8·5 | 9·4 | 50 | 11·2 | — |
| | | 7–12 | 100 | 23·9 | 33·2 | 98 | 21·8 | 31·2 | 104 | 23·3 | 34·5 |
| | | 13–18 | 82 | 19·6 | 52·8 | 78 | 17·4 | 48·6 | 87 | 19·5 | 54·0 |
| | | 19–24 | 48 | 11·5 | 64·3 | 57 | 12·7 | 61·3 | 46 | 10·3 | 64·3 |
| | | 25–48 | 86 | 20·5 | 84·8 | 86 | 19·2 | 80·5 | 81 | 18·1 | 82·4 |
| | | 49–78 | 34 | 8·1 | 92·9 | 52 | 11·6 | 92·1 | 29 | 6·5 | 88·9 |
| | | 79–156 | 19 | 4·5 | 97·4 | 20 | 4·5 | 96·6 | 26 | 5·8 | 94·7 |
| | | 157–312 | 7 | 1·7 | 99·1 | 11 | 2·4 | 99·0 | 14 | 3·1 | 97·8 |
| | | 312+ | 4 | ·9 | 100·0 | 5 | 1·0 | 100·0 | 10 | 2·2 | 100·0 |
| | | Total | 419 | 100·0 | — | 449 | 100·0 | — | 447 | 100·0 | — |

TABLE IV

NUMBER OF SPELLS FOR BRONCHITIS LASTING MORE THAN A YEAR, BY AGE AND SEX (20 PER CENT. SAMPLE)

| Sex | Men | | | Women | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Married | | | Other | | |
| Age Group (yrs) | 1954–55 | 1955–56 | 1956–57 | 1954–55 | 1955–56 | 1956–57 | 1954–55 | 1955–56 | 1956–57 |
| 20–29 | 7 | 4 | 3 | 3 | 4 | 3 | 3 | 3 | 4 |
| 30–39 | 6 | 6 | 5 | 7 | 12 | 9 | 2 | 2 | 3 |
| 40–49 | 24 | 18 | 17 | 7 | 14 | 12 | 12 | 13 | 7 |
| 50–59 | 96 | 92 | 76 | 15 | 14 | 15 | 10 | 15 | 14 |
| 60–64 | 46 | 62 | 57 | — | — | — | — | — | — |
| Total | 179 | 182 | 158 | 32 | 44 | 39 | 27 | 33 | 28 |
| Total per 1,000 Exposed to Risk | 2·6 | 2·7 | 2·3 | 4·0 | 5·5 | 4·9 | 1·2 | 1·4 | 1·2 |

These Tables are of considerable general interest, especially because the expected pattern is disturbed by the experience of married women. When one considers that the mortality rate for bronchitis in Northern Ireland is appreciably greater for men than for women, it is surprising that this is not reflected in the inception rates and long-term rates in this morbidity experience. The ratio of male to female mortality at all ages is about 3 : 1. In married women as a class it may be true to say that the duration of incapacity for work may be determined by factors unrelated to health.

It is appreciated that with the limited numbers available it is impossible to draw firm conclusions.

However, a broad pattern is given indicating general trends and the approximate size of the problem. It is estimated that for the year ending April 31, 1958, the number of working days lost through bronchitis in Northern Ireland was 820,000. In the absence of data on occupation it has been impossible to give information on social class experience in Northern Ireland. Regionalized statistics will shortly be available and these will be of assistance in relating this disease to environment and atmospheric pollution. It is not possible with the data at present available to consider seasonal variations, which would enable a comparison to be made with mortality experience and climatic conditions, but further studies of the problem of bronchitis in Northern Ireland are at present under consideration from many angles.

Out thanks are due to Dr. E. A. Cheeseman, Department of Social and Preventive Medicine, Queen's University of Belfast, for his help and guidance in this study and to Dr. F. F. Main, Chief Medical Officer, Ministry of Health and Local Government, for permission to publish this paper.

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# SOCIAL CLASS DISTRIBUTION OF RESPIRATORY TUBERCULOSIS NOTIFICATIONS IN NORTHERN IRELAND, 1949-53

BY

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Recently the social class distribution of respiratory tuberculosis mortality for males in Northern Ireland has been examined for the first time, using deaths in the period 1949–53 and the 1951 census population (Merrett, 1959). This paper presents the social class distribution of respiratory tuberculosis morbidity, as measured by notifications, for males in Northern Ireland during the same period.

The Northern Ireland Tuberculosis Authority is responsible for the prevention and treatment of tuberculosis for the whole country (*Brit. med. J.*, 1954; Cheeseman, 1956; Elder, 1953) and their records include respiratory tuberculosis notifications classified by age, sex, and "state of disease" for each year since 1948. Patients diagnosed as having active primary tuberculosis were excluded from the published notifications from 1952 onwards, but the numbers of such patients have been made available to me and are included in the notifications occurring in the period 1949–53 which have been used in the following analysis (Northern Ireland Tuberculosis Authority, 1957). The Authority has further provided details of occupations followed by notified persons at the time of diagnosis.

The "state of disease" classification used by the Authority is that suggested for England and Wales by the Ministry of Health (1947), namely:

*Group* 1.—Cases with slight constitutional disturbances.

*Group* 2.—All cases which cannot be placed in Groups 1 and 3.

*Group* 3.—Cases with profound systematic disturbance or constitutional deterioration and with marked impairment of function, either local or general.

Throughout this report these will be referred to as Stage 1, Stage 2, and Stage 3.

The method used for classifying occupations and thence social class is that used by the General Register Office (1956).

## Material

In Northern Ireland in 1949–53 there were 4,702 notifications of respiratory tuberculosis among males; of these, 3,777, whose age, social class, and "state of disease" were known, were aged 15 years and over. Of the 3,777 male notifications included in this report, 3,532 (93·5 per cent.) were classified as "occupied or retired" and the remaining 245 (6·5 per cent.) as "unoccupied", these terms being used in the same sense as in the official reports for England and Wales (*e.g.* Registrar General, 1958). The "unoccupied" group does not include persons who are out of work; they are classified by their last occupation and included in the "occupied or retired" group. These proportions are very similar to those found in the analysis of deaths from respiratory tuberculosis in Northern Ireland from 1949–53 (Merrett, 1959), when 95·5 per cent. of the deaths were classified as "occupied or retired" and 4·5 per cent. as "unoccupied".

Classification by social class resulted in 61 notifications in Social Class I (Professional), 416 in Class II ("Intermediate"), 1,761 in Class III (Skilled), 639 in Class IV (Partly-skilled), and 665 in Class V (Unskilled). The distribution of notifications by state of disease and social class is shown in Table I.

TABLE I

NUMBER OF NOTIFICATIONS OF RESPIRATORY TUBERCULOSIS IN MALES AGED 15 YEARS AND OVER IN NORTHERN IRELAND (1949–53) BY SOCIAL CLASS AND STAGE OF DISEASE

| Social Class | Stage of Disease | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 1 | | 2 | | 3 | | Total | |
| | No. | Per cent. | No. | Per cent. | No. | Per cent. | No. | Per cent. |
| I | 23 | 37·7 | 28 | 45·9 | 10 | 16·4 | 61 | 100 |
| II | 133 | 32·0 | 201 | 48·3 | 82 | 19·7 | 416 | 100 |
| III | 608 | 34·7 | 850 | 48·5 | 293 | 16·7 | 1,751 | 100 |
| IV | 223 | 34·9 | 274 | 42·9 | 142 | 22·2 | 639 | 100 |
| V | 161 | 24·2 | 345 | 51·9 | 159 | 23·9 | 665 | 100 |
| Unoccupied | 93 | 38·0 | 88 | 35·9 | 64 | 26·1 | 245 | 100 |
| Total .. | 1,241 | 32·9 | 1,786 | 47·3 | 750 | 19·9 | 3,777 | 100 |

## Results

The percentage distributions of Table I show that, as the social class becomes less favourable, notifications of more advanced tuberculosis (Stage 3) become relatively more common than those of early disease (Stage 1).

Table II shows the standardized morbidity ratios for all males aged 15 years and over, irrespective of state of disease, and for each stage separately. These ratios could unfortunately mask age differences which have already been reported by other workers (Lowe, 1954; Cheeseman, 1956; Department of Health for Scotland, 1958). This Table is only included for the sake of interest, and from what follows it will be seen that the ratios would have been unreliable for depicting the social class variation in notification rates in some age groups. The average annual notification rates for specified age groups are shown in Table III (opposite) for each social class and stage of disease. This breakdown resulted in a small number of notifications in some age and social class groups, especially in Social Class I and in the older age groups of the other social classes. These rates have been accepted at their face value, but it must be remembered that they may be unreliable.

*All Notifications Combined.*—For all notifications combined, there is no consistent social class trend apparent in each age group shown in Table III; thus at different ages different social classes have the maximum rates. The maxima appear twice in Social Classes II and III, once in Social Class IV, and four times in Social Class V.

Cheeseman (1956) found that the notification rates for Northern Ireland had two peaks, a major peak occurring at 20–24 years and a minor peak at 50–54 years. This has also been shown for respiratory tuberculosis notifications of males in Scotland (Department of Health for Scotland, 1958), where the notification rates for 1956 had peaks at ages 15–24 and 45–64 years. This is consistent with the present data where each social class clearly has a peak between ages 15 and 24. As social class becomes less favourable, the second peaks become more clearly defined. In Social Class III the minor peak occurs at 55–59 years and in Social Class V the major peak at 55–59 years (Fig. 1, overleaf). Social Class IV is intermediate between III and V, the difference between the heights of the peaks being small. A striking feature of Social Class II morbidity is the very high rates for the two youngest age groups, but it should be noted that, as the rate for age 15–19 years is based on a small number of notifications, it is possible that the true peak is attained in the next age group, 20–24 years, which has the second highest notification rate. In the present study the rates of Social Class I are based on small numbers and no really definable age distribution is possible, although the maximum rate occurred in the age group 20–24 years.

The reliable rates thus imply that the age morbidity curve with a single peak at early adult ages, which is typical of males in the high social classes, changes as the social class becomes less favourable to a bimodal curve with the major peak at about age 55 or over. Thus, as social class becomes less favourable, morbidity at older ages become greater than at younger ages. The social class and age relationship was then examined for the three stages of severity of the disease.

Table II

STANDARDIZED MORBIDITY RATIOS AND THEIR STANDARD ERRORS BASED ON THE NOTIFICATIONS OF RESPIRATORY TUBERCULOSIS IN MALES AGED 15 YEARS AND OVER IN NORTHERN IRELAND (1949–53), BY STAGE OF DISEASE AND SOCIAL CLASS

| Stage of Disease | Social Class | | | | | |
|---|---|---|---|---|---|---|
| | I | II | III | IV | V | Unoccupied |
| | S.M.R. ± S.E.* | S.M.R. ± S.E. | S.M.R. ± S.E. | S.M.R. ± S.E. | S.M.R. ± S.E. | S.M.R. ± S.E. |
| All Notifications | 73 ± 9·3 | 60 ± 2·9 | 119 ± 2·8 | 84 ± 3·3 | 113 ± 4·4 | 135 ± 8·6 |
| 1 | 96 ± 20·1 | 80 ± 6·9 | 120 ± 4·9 | 84 ± 5·6 | 85 ± 6·7 | 103 ± 10·7 |
| 2 | 67 ± 12·6 | 56 ± 4·0 | 123 ± 4·2 | 78 ± 4·7 | 123 ± 6·6 | 136 ± 14·5 |
| 3 | 56 ± 17·8 | 48 ± 5·3 | 107 ± 6·2 | 100 ± 8·4 | 134 ± 10·7 | 239 ± 29·9 |

* Standardized morbidity ratios ± standard error.

*Stage 1.*—Social Class III has the greatest morbidity at all ages combined (Table III). However, this is not consistent in each age group. In no single age group did Social Class III have the highest rate, but in seven it has the second highest. No other social class consistently has the greatest rate and, as Table III shows, the maximum rate occurred in two age groups in each of the Social Classes I, II and V and in three age groups in Class IV. Each social class showed a major peak between ages 15–24 (Fig. 2, Stage 1, overleaf), but there is a suggestion of a minor peak at a later age in the lower social classes. In these classes (IV and V) the difference in the rates at the younger and the older ages is not as great as in the other social classes.

Lowe (1954), in his survey of Birmingham notifications for 1951, and Cheeseman (1956) both found in their respective studies of Stage 1 notifications that maximum morbidity for males occurred at age 15–19 years. There is also some evidence of a very much lower peak in Lowe's data at age 50–54 years.

*Stage 2.*—The age distribution of the notification rates of this stage is characterized by its two peaks. This has already been reported by other writers. Cheeseman (1956) showed that the major peak occurred at age 20–24 years and the minor, which was slightly smaller than the major, at age 50–54 years. The major peak in the data discussed by Lowe (1954) also occurred at age 20–24 years and an appreciably smaller minor peak at age 45–49 years. In the present data this bimodal characteristic is much more marked in each of Social Classes III, IV, and V than in either of the two remaining classes. In fact, as social class lowered, the major peak occurred at an older age and was markedly higher than the minor peak in the lowest social class (Fig. 2, Stage 2). It is also of interest that in Social Class V males between the ages of 35 and 65 years consistently have the greatest morbidity rate of all the social classes.

*Stage 3.*—As there are only ten Stage 3 notifications in Social Class I, this class has been omitted from the following results in this group, although

TABLE III

RESPIRATORY TUBERCULOSIS MORBIDITY AMONG MALES IN NORTHERN IRELAND (1949–53), BY AGE, SOCIAL CLASS, AND STAGE OF DISEASE

Average annual notification rates per 100,000 of the population at stated age group in years

| Stage of Disease | Social Class | Age Group (yrs) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 15–19 | 20–24 | 25–34 | 35–44 | 45–54 | 55–59 | 60–64 | 65–69 | 70 and Over | Total 15 and Over |
| All Notifications | I | (72) | (191) | (154) | (86) | (142) | (53) | (102) | (112) | (—) | 112 |
| | II | (362) | 313 | 143 | 87 | 84 | 49 | 50 | (33) | (15) | 83 |
| | III | 266 | 282 | 214 | 153 | 187 | 209 | 175 | 115 | (18) | 198 |
| | IV | 132 | 181 | 134 | 154 | 158 | 141 | 150 | (97) | (27) | 138 |
| | V | 155 | 211 | 178 | 172 | 237 | 264 | 183 | (109) | (26) | 181 |
| | Unoccupied | 140 | (197) | (117) | (21) | (103) | (310) | (544) | 2,201 | 1,266 | 243 |
| 1 | I | (72) | (95) | (89) | (31) | (20) | (—) | (—) | (37) | (—) | 42 |
| | II | (201) | 154 | 64 | 25 | (16) | (9) | (3) | (5) | (2) | 27 |
| | III | 159 | 137 | 73 | 35 | 37 | (26) | (19) | (16) | (2) | 69 |
| | IV | 83 | 71 | 56 | 41 | 37 | (21) | (24) | (11) | (9) | 48 |
| | V | 67 | 71 | 53 | 40 | 43 | (37) | (20) | (13) | (—) | 44 |
| | Unoccupied | 94 | (135) | (70) | (—) | (17) | (62) | (42) | (503) | (107) | 92 |
| 2 | I | (—) | (72) | (65) | (39) | (102) | (—) | (68) | (—) | (—) | 51 |
| | II | (80) | 126 | 62 | 48 | 50 | (20) | (20) | (18) | (9) | 40 |
| | III | 78 | 119 | 114 | 85 | 106 | 122 | 86 | 79 | (6) | 96 |
| | IV | (30) | 81 | 55 | 68 | 80 | (72) | (73) | (64) | (9) | 59 |
| | V | 60 | 100 | 90 | 102 | 116 | 171 | 104 | (58) | (9) | 94 |
| | Unoccupied | 36 | (52) | (47) | (—) | (68) | (62) | (335) | (818) | 553 | 87 |
| 3 | I | (—) | (24) | (—) | (16) | (20) | (53) | (34) | (75) | (—) | (18) |
| | II | (80) | (33) | (17) | (14) | (18) | (20) | (28) | (10) | (4) | 16 |
| | III | 29 | 26 | 27 | 33 | 44 | 61 | 69 | (20) | (10) | 33 |
| | IV | (19) | (29) | 22 | 45 | 42 | (47) | (53) | (21) | (9) | 31 |
| | V | (29) | (40) | 35 | 30 | 77 | (57) | (59) | (39) | (17) | 43 |
| | Unoccupied | (10) | (10) | (—) | (21) | (17) | (186) | (167) | (881) | 606 | 64 |
| 2 and 3 | I | (—) | (95) | (65) | (54) | (122) | (53) | (102) | (75) | (—) | 70 |
| | II | (161) | 159 | 80 | 62 | 68 | (40) | (48) | (28) | (12) | 56 |
| | III | 107 | 145 | 141 | 118 | 150 | 182 | 155 | 99 | (16) | 129 |
| | IV | 49 | 110 | 77 | 113 | 122 | 119 | 126 | (86) | (18) | 90 |
| | V | 88 | 140 | 125 | 132 | 193 | 227 | 164 | (97) | (26) | 137 |
| | Unoccupied | 46 | (62) | (47) | (21) | (85) | (248) | (502) | 1,698 | 1,159 | 151 |

Figures in brackets are based on less than twenty notifications.

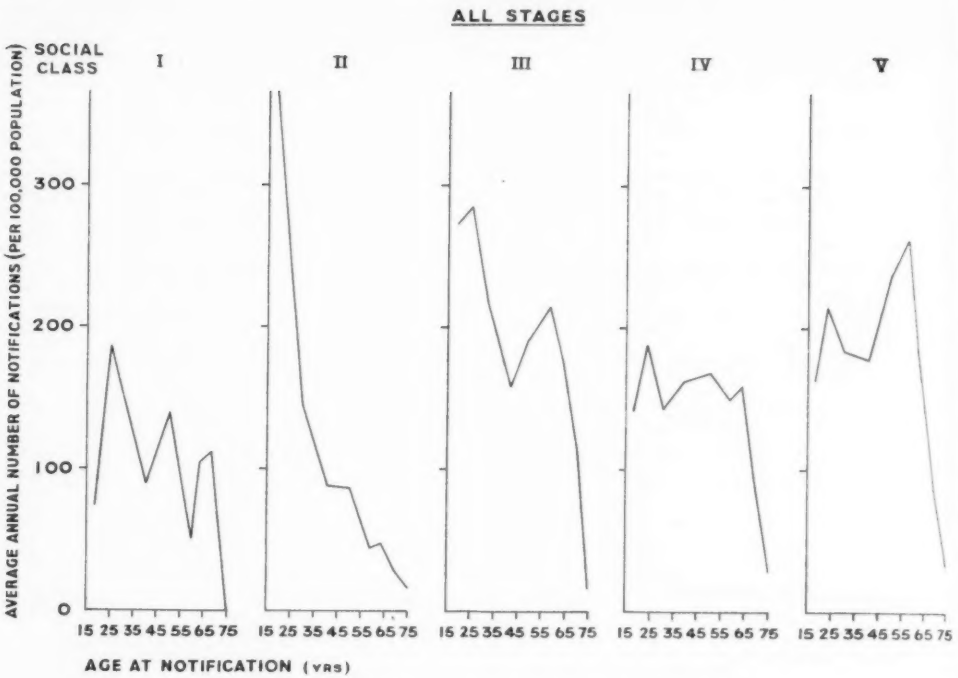


FIG. 1.—Notification rates of respiratory tuberculosis in Northern Ireland, 1949–53

the rates for Social Class I are shown in Table III and in Fig. 2, Stage 3. Morbidity is greatest in five of the nine age groups in Social Class V, in two in Class III, and in one in each of Classes II and IV, and there is no consistent run of maximum rates in any one social class. There is evidence of a bimodal distribution in each of the four social classes, and in the lower classes the major peak tends to occur at a later age than in the higher classes. This is evident from Fig. 2, Stage 3, and a point worthy of note is that the major peak occurs earlier in the unskilled occupations (Social Class V), namely at age 45–54 years compared with age 60–64 years for Social Classes III and IV. Social Class II also showed a slight tendency to have a second peak in the earlier age group (45–54 years), but this is less marked than in the other social classes.

*Comparison between Stages of Disease.*—This analysis would be incomplete without a comparison of the notification rates between the stages of disease for each age and social class. Up to age 25 years, the rates in Stage 1 are greater than those in Stage 3 for all social classes, the difference being least in the partly-skilled and unskilled occupations. With the exception of males aged 20–24 years in Social Classes IV and V, where Stage 2 has the maximum rate, the Stage 2 rates are greater than those of Stage 3 but less than those of Stage 1. From 25 to 44 years the rates for Stage 1 are again higher than those for Stage 3 except for partly-skilled males aged 35–44 years, the difference being least in the lower social classes. Except in the higher social classes the rates for the intermediate Stage 2 are greater than those of the other two stages.

After age 45, except in a few age and social class groups where the number of notifications is small, the Stage 2 rates are the greatest, with Stage 3 greater than Stage 1.

Thus, as age increases so do the notifications of more serious tuberculosis, and this holds for each social class.

*Unoccupied Group.*—Reference to the unoccupied group has so far been omitted, mainly because the number of notifications of males between the age of

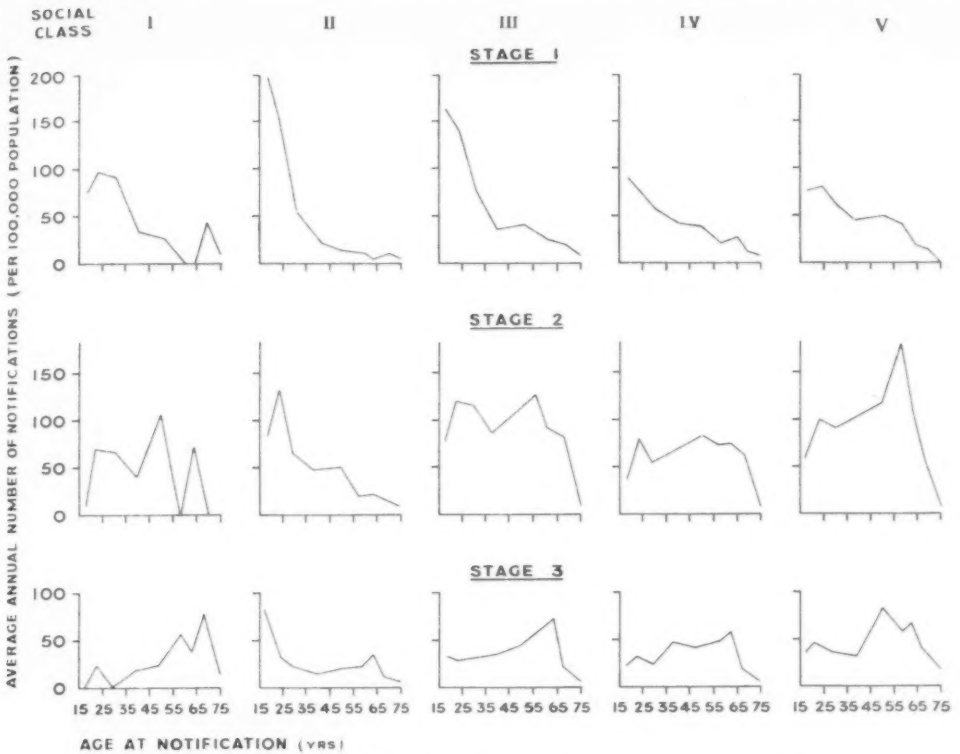


FIG. 2.—Classified notification rates of respiratory tuberculosis in Northern Ireland, 1949–53.

20–64 is so small as to make it risky to draw any conclusion from them. Moreover, 85 (34·7 per cent.) of this group were aged 15–19 and 106 (43·3 per cent.) were aged 65 years and over. Most of the 85 were still at school or had not yet started their first employment, and it is only in this group of the "unoccupied" that any confidence can be placed in the rates. As was to be expected, the majority of these 85 were in the early stages of the disease (Stage 1), the average annual notification rates being 94, 36, and 10 per 100,000 of the population for Stages 1, 2, and 3 respectively. For age 65 years and over the occupations of all but one of the males were stated as "persons of leisure, retired". It is unlikely that this number had never been employed; probably if the truth were known most of these 105 should be re-allocated to the other social classes, in which case the average annual notification rates are understated in the last two age groups in each of the social classes. Unfortunately the amount of this understatement cannot be estimated. Of the 105 stated to be "persons of leisure, retired", fourteen (13·3 per cent.) were classified as Stage 1, 44 (41·9 per cent.) as Stage 2, and 47 (44·8 per cent.) as Stage 3.

## DISCUSSION

In Northern Ireland the investigation of respiratory tuberculosis is for the most part carried out by the chest clinics and mass radiography units. Approximately 15 per cent. of the population in Northern Ireland is examined radiologically annually and many of these are persons who are examined every year in organized groups. Thus the number of people seen for the first time each year is only a small percentage of the population and is not fully

representative of the population from which it is drawn. In view of the findings of Bradbury (1948) that, even with 70 per cent. of the population being examined radiologically, only 50 per cent. of the tuberculous would be discovered, the notification rates discussed earlier may well underestimate the true incidence of respiratory tuberculosis in Northern Ireland. This would seem to apply mainly to Stage 1 disease, which by definition involves only slight constitutional disturbance and is very often symptomless so that it is detected mainly by mass radiography and by the examination of contacts of other affected persons. During most of the period concerned the policy of the mass radiography service in Northern Ireland was such that efforts were largely concentrated on young adults in industry. This is apparent from Table IV, which shows that, for 1951, the middle year of the period examined, the greatest proportion of the male population examined was between the ages of 15 and 24 years. This may explain at least in part the small difference in the total morbidity rates for Social Classes III and V. This difference is largely due to the higher notification rates of Stage 1 disease in the younger age groups of Social Class III males. If, because of the present policy already mentioned, a greater proportion of the skilled than unskilled trades is being examined by mass radiography in the young adult male age groups, then this apparent difference in social class morbidity might be more easily understood. Unfortunately no data are available to enable a comparison to be made of the proportions examined radiologically in each social class.

TABLE IV

MASS RADIOGRAPHY OF MALES IN NORTHERN IRELAND IN 1951

| Age Group (yrs) | Number *x*-rayed | Percentage of Northern Ireland Population *x*-rayed |
|---|---|---|
| Under 15 | 6,527 | 3·4 |
| 15–24 | 11,712 | 11·2 |
| 25–34 | 7,866 | 8·5 |
| 34–44 | 5,233 | 5·9 |
| 45–59 | 4,083 | 3·9 |
| 60 and Over | 728 | 0·9 |
| Total .. .. | 36,149 | 5·4 |

Stage 2 notifications should contain no symptomless people and may well be considered with the more advanced type of the disease (Stage 3) as progressive stages after the time when symptoms first appear. The notification of these two stages depends largely on the attitude of the affected males. Some will seek early advice and others will delay, the former being more likely to be diagnosed as Stage 2 and the latter as Stage 3. This is partially borne out by the fact that, except in the unskilled occupations and to a lesser degree in Social Class IV of the present data, the maximum rate occurred at an earlier age for Stage 2 than for Stage 3 notifications. The reverse is true, however, of Social Class V, where the maximum rate occurred some 10 years earlier in Stage 3 than in Stage 2.

It seems likely, therefore, that Stage 2 and Stage 3 cases considered together would yield rates approximating closely to the true morbidity rates in males aged 15 and over for respiratory tuberculosis in which symptoms are manifest. These combined rates are shown in Table III, which shows that the highest rate occurs in the age group 45–54 years for Social Class I, but in view of the small number of notifications involved no great importance should be attached to this. Social Class II rates, however, show a tendency to decrease from the youngest age group surveyed. Social Classes III and V both show a bimodal distribution, the peaks occurring at ages 20–24 and 55–59 years, the latter being the major peak in each case. Social Class IV also has a peak at age 20–24 years and, although the major peak is less clearly defined, the maximum rate occurs at 60–64 years. After age 34 Social Class V experiences the highest morbidity and Social Classes I and II have rates consistently lower than Classes III to V.

As age advances, the proportion of respiratory tuberculosis with symptoms diagnosed increases in each of the social classes (Table V, opposite). This is not unexpected, but it is worthy of note that, even in the younger age groups, the proportion of advanced cases to the total cases of tuberculosis notified is greater in Social Class V than in the other social classes. This might well be due to a real difference in the morbidity experience of the various social classes. Alternatively, it might be explained if relatively fewer unskilled men in these age groups were being examined radiologically. If this were so, fewer cases would be classified in Stage 1 in the younger age groups in Social Class V and Stage 2 and 3 notifications would predominate.

Since persons dying from respiratory tuberculosis may be considered as either Stage 2 or Stage 3 cases, the morbidity in this combined group may reflect the mortality trend. As a crude test the standardized morbidity ratios for Stages 2 and 3 combined and the mortality ratios for males in Northern Ireland and the standardized mortality ratios for males in England and Wales are shown in Table VI (opposite). The ratios for morbidity and mortality are similar for Social Classes I, II, and III in Northern Ireland, but differ widely in the partly-skilled and unskilled occupations. In the comparison of Northern Ireland morbidity with England and Wales mortality, the

TABLE V

NOTIFICATION RATES OF STAGES 2 AND 3 COMBINED AS A PERCENTAGE OF THE CORRESPONDING RATE FOR ALL NOTIFICATIONS

| Social Class | Age Group (yrs) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 15–19 | 20–24 | 25–34 | 35–44 | 45–54 | 55–59 | 60–64 | 65–59 | 70 and Over | Total 15 and Over |
| I | (0) | (50) | (42) | (63) | (86) | (100) | (100) | (67) | (*) | 63 |
| II | (44) | 51 | 56 | 71 | 81 | 82 | 96 | (85) | (80) | 67 |
| III | 40 | 51 | 66 | 77 | 80 | 87 | 89 | 86 | (89) | 65 |
| IV | 37 | 61 | 57 | 73 | 77 | 84 | 84 | (89) | (67) | 65 |
| V | 57 | 66 | 70 | 77 | 81 | 86 | 89 | (89) | (100) | 77 |

* No notifications.
Figures in brackets show percentages whose denominator is based on less than twenty notifications.

TABLE VI

COMPARISON OF STANDARDIZED MORBIDITY RATIOS FOR MALES IN NORTHERN IRELAND WITH STANDARDIZED MORTALITY RATIOS IN NORTHERN IRELAND AND ENGLAND AND WALES FOR RESPIRATORY TUBERCULOSIS (1949–53)

| Social Class | Northern Ireland | | England and Wales* |
|---|---|---|---|
| | Standardized Morbidity Ratio ± S.E. | Standardized Mortality Ratio ± S.E. | Standardized Mortality Ratio ± S.E. |
| I | 64 ± 10·3 | 63 ± 14·1 | 58 ± 2·3 |
| II | 54 ± 3·2 | 49 ± 3·9 | 63 ± 1·1 |
| III | 118 ± 3·5 | 112 ± 5·0 | 102 ± 0·8 |
| IV | 84 ± 4·1 | 51 ± 4·7 | 95 ± 1·4 |
| V | 127 ± 5·6 | 203 ± 10·1 | 143 ± 1·8 |

* Based on ages 20–64 years.

ratios are much more alike for each social class. This, I feel, gives more weight to the arguments previously put forward (Merrett, 1959), that insufficient information about occupation, especially of the partly-skilled and unskilled workers, is being given to the registrars in Northern Ireland at death registration.

## SUMMARY

It seems advisable to consider the notifications of males with respiratory tuberculosis in two parts; cases with few or no symptoms (Stage 1), and cases with symptoms usually noticed by the patients themselves (Stages 2 and 3). For the former, the maximum rates occurred between the ages of 15 and 24 years for all social classes, the rates in this age range being the lowest of all for Social Class V.

Maximum morbidity occurred much later in life for moderate or advanced cases (Stages 2 and 3), except for Social Class II which had the greatest notification rate between the ages of 15 and 24 years. Social Classes III, IV, and V all experienced their maximum notification rate between the ages of 55 and 64, and there was evidence of a minor peak in each of these classes between the ages of 20 and 24 years. After the age of 35, the males of Social Class V consistently experienced a greater morbidity than those of the other social classes, except at age 65–69.

The proportion of male notifications of moderate or advanced disease increases with age and this is true of all social classes. This suggests that fewer diagnoses of Stage 1 disease are being made from radiological findings in the older age groups. Social Class V also had a greater proportion of advanced cases of respiratory tuberculosis in the youngest age groups (*i.e.* 15–34 years) than the other social classes.

The differences noted above may be indications of the true morbidity of the social classes in Northern Ireland, but they may also reflect the present policy of the mass radiography units in this country to concentrate on the young adults in industry. In view of the present findings, if the morbidity from respiratory tuberculosis in the Northern Ireland population is to be deduced from notification rates, it would seem advisable to examine radiologically a sample of the population more representative with regard to age and social class.

I should like to thank the Secretary of the Northern Ireland Tuberculosis Authority and his staff for providing the hitherto unpublished notification data used in this report. My thanks are also due to Mrs. Dorothy Hutton for typing the manuscript and to Miss Betty Thornbury for preparing the figures.

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*Brit. J. prev. soc. Med.* (1959), **13**, 222–226

# SECULAR PATTERN OF CONGENITAL OESOPHAGEAL ATRESIA

BY

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There is a common superstition among hospital staffs that rare diseases tend to come in groups. One possible explanation for this belief may be found in the character of the frequency distribution of lengths of intervals between successive events occurring at random. In contrast with the distributions of everyday experience, where, for example, a very short man is also an uncommon man, the distribution of random intervals is exponential, and the intervals become more frequent as they get shorter and further from the mean. The unfamiliarity of this pattern could easily produce impressions of grouping, and our chief difficulty is not in detecting groups of illnesses but in distinguishing random groups from those which could not reasonably be attributed to chance.

The present paper is an exercise in such distinction.

Oesophageal atresia and tracheo-oesophageal fistula commonly occur in the same child and may be considered together as a relatively uncommon congenital malformation. Yet Gross (1953) was able to show on a single photograph no fewer than nine children who were patients at the Children's Hospital, Boston, for the treatment of this condition. At least six appear to be very young infants, presumably having a primary repair, and other statistics given suggest that this represents a remarkable coincidence of events. Indeed, it supplies a concise statement of the specific problem with which this paper is concerned.

TABLE I

35 CASES OF OESOPHAGEAL ATRESIA/TRACHEO-OESOPHAGEAL FISTULA IN BIRMINGHAM

| Date of Birth | Day Number | Preceding Interval (days) |
|---|---|---|
| 19. 6.50 | 170 | 170 |
| 12.11.50 | 316 | 146 |
| 21. 3.51 | 445 | 129 |
| 13. 4.51 | 468 | 23 |
| 26. 7.52 | 938 | 470 |
| 30.10.52 | 1,034 | 96 |
| 1. 2.53 | 1,128 | 94 |
| 17. 5.53 | 1,233 | 105 |
| 1. 6.53 | 1,248 | 15 |
| 2. 6.53 | 1,249 | 1 |
| 5. 6.53 | 1,252 | 3 |
| 12. 6.53 | 1,259 | 7 |
| 20. 6.53 | 1,267 | 8 |
| 28. 7.53 | 1,305 | 38 |
| 16.10.53 | 1,385 | 80 |
| 19.10.53 | 1,388 | 3 |
| 21.10.53 | 1,390 | 2 |
| 16.12.53 | 1,446 | 56 |
| 24.12.53 | 1,454 | 8 |
| 28.12.53 | 1,458 | 4 |
| 31.12.53 | 1,461 | 3 |
| 30. 1.54 | 1,491 | 30 |
| 2. 5.54 | 1,583 | 92 |
| 26. 8.54 | 1,699 | 116 |
| 29. 8.54 | 1,702 | 3 |
| 22.11.54 | 1,787 | 85 |
| 8. 4.55 | 1,924 | 137 |
| 28. 5.55 | 1,974 | 50 |
| 11. 8.55 | 2,049 | 75 |
| 13. 8.55 | 2,051 | 2 |
| 29. 8.55 | 2,067 | 16 |
| 6. 9.55 | 2,075 | 8 |
| 9.10.55 | 2,108 | 33 |
| 21.11.55 | 2,151 | 43 |
| 14.12.55 | 2,174 | 23 |
| End of Period | 2,191 | 17 |
| Total Number of Days .. .. .. | | 2,191 |

## MATERIAL

Two groups of children have been studied:

(1) All cases of tracheo-oesophageal fistula and/or oesophageal atresia admitted to the Birmingham Children's Hospital in the years 1950 to 1955 (Table I);

(2) All cases recorded at the Royal Victoria Infirmary, Newcastle General Hospital, Babies' Hospital, Fleming Memorial Hospital, and Princess Mary Maternity Hospital (all at Newcastle-upon-Tyne), at Dryburn Hospital, Durham, and at the Department of Thoracic Surgery, Shotley Bridge

General Hospital, in the years 1950 to 1958 (Table II).

TABLE II

63 CASES OF OESOPHAGEAL ATRESIA/TRACHEO-OESOPHAGEAL FISTULA IN THE NEWCASTLE REGION

| Date of Birth | Day Number | Preceding Interval (days) |
|---|---|---|
| 15. 2.50 | 46 | 46 |
| 7. 1.51 | 372 | 326 |
| 12. 1.51 | 377 | 5 |
| 26. 2.51 | 422 | 45 |
| 19. 5.51 | 504 | 82 |
| 12. 6.51 | 528 | 24 |
| 20. 8.51 | 597 | 69 |
| 6.11.51 | 675 | 78 |
| 29.11.51 | 698 | 23 |
| 22.11.52 | 1,056 | 358 |
| 16. 2.53 | 1,143 | 87 |
| 15. 7.53 | 1,292 | 149 |
| 24. 7.53 | 1,301 | 9 |
| 9. 8.53 | 1,317 | 16 |
| 14. 9.54 | 1,718 | 401 |
| 20. 9.54 | 1,724 | 6 |
| 29.11.54 | 1,794 | 70 |
| 8. 1.55 | 1,834 | 40 |
| 17. 1.55 | 1,843 | 9 |
| 30. 1.55 | 1,856 | 13 |
| 5. 2.55 | 1,862 | 6 |
| 8. 2.55 | 1,865 | 3 |
| 21. 2.55 | 1,878 | 13 |
| 24. 3.55 | 1,909 | 31 |
| 25. 3.55 | 1,910 | 1 |
| 27. 3.55 | 1,912 | 2 |
| 26. 4.55 | 1,940 | 28 |
| 16. 5.55 | 1,962 | 22 |
| 19. 7.55 | 2,026 | 64 |
| 22. 7.55 | 2,029 | 3 |
| 11. 9.55 | 2,080 | 51 |
| 29.10.55 | 2,128 | 48 |
| 14.11.55 | 2,144 | 16 |
| 6. 1.56 | 2,197 | 53 |
| 28. 1.56 | 2,219 | 22 |
| 9. 3.56 | 2,260 | 41 |
| 13. 5.56 | 2,325 | 65 |
| 17. 5.56 | 2,329 | 4 |
| 20. 5.56 | 2,332 | 3 |
| 24. 5.56 | 2,336 | 4 |
| 11. 7.56 | 2,384 | 48 |
| 26. 9.56 | 2,461 | 77 |
| 22.11.56 | 2,518 | 57 |
| 2.12.56 | 2,528 | 10 |
| 15. 2.57 | 2,603 | 75 |
| 10. 3.57 | 2,626 | 23 |
| 14. 5.57 | 2,691 | 65 |
| 15. 5.57 | 2,692 | 1 |
| 20. 8.57 | 2,789 | 97 |
| 19. 9.57 | 2,819 | 30 |
| 2.10.57 | 2,832 | 13 |
| 1. 1.58 | 2,923 | 91 |
| 28. 5.58 | 3,070 | 147 |
| 29. 5.58 | 3 071 | 1 |
| 11. 6.58 | 3,084 | 13 |
| 23. 6.58 | 3,096 | 12 |
| 28. 6.58 | 3,101 | 5 |
| 14. 8.58 | 3,148 | 47 |
| 12. 9.58 | 3,177 | 29 |
| 17. 9.58 | 3,182 | 5 |
| 16.10.58 | 3,211 | 29 |
| 28.11.58 | 3,254 | 43 |
| 21.12.58 | 3,277 | 23 |
| End of Period | 3,287 | 10 |
| Total Number of Days .. .. .. | | 3,287 |

All the Birmingham children were liveborn, but two stillborn infants with the condition are included in the Newcastle group.

There were 35 cases at Birmingham in 6 years and 63 in the Newcastle hospitals in 9 years.

In neither series is it supposed that a defined population is represented or that ascertainment is complete. In recent years the recognition of the disease has been improving, so that in any series we can presume that earlier records are less complete than later ones, and since current standards of diagnosis are not uniform we must suppose that even recent records are incomplete.

The dates of birth of the Birmingham and Newcastle babies given in Tables I and II are grouped by year and month in Tables III and IV (overleaf).

## ANALYSIS

It is immediately obvious that neither series is random. In both groups there is wide variation between the numbers occurring in different years:

Birmingham $\chi^2_{(5)} = 23{\cdot}9$; $P<0{\cdot}001$;

Newcastle $\chi^2_{(8)} = 31{\cdot}4$; $P<0{\cdot}001$.

Both sets of annual totals show a general rise in recorded incidence with time and a possible reason for this, or at least a contributing reason, has already been suggested.

In neither group, however, does a linear trend supply an adequate description of the series of annual totals, both series showing highly significant deviations about the calculated regressions.

The combined data of both series show no evidence of a seasonal cycle.

Superimposed upon the pattern of an irregular increase can be seen (see Tables III and IV) the groups constituting the problem which is the subject of this paper:

In Birmingham, there occurred three close groups in the Summer, Autumn, and Winter of 1953, a close pair of cases in 1954, and another less striking concentration in the late Summer of 1955.

In Newcastle the more striking groups were in January, 1951, the Summer of 1953, and the Spring or Summer of each year from 1955 to 1958.

These irregularly recurring groups, combined with the evident irregularity and non-linearity of the annual totals, suggest a non-random element over and above anything which could be attributed to improving ascertainment.

Unfortunately, no established significance test appears to be directly applicable, and the formal examination of the situation depends upon *ad hoc* methods with the accompanying logical difficulties which arise when there is a wide choice of tests and no prior reasons for using any particular one preferentially.

The simplest method of constructing a numerical picture of the extent of the concentrations is to draw up the distribution of numbers of cases occurring

TABLE III

OESOPHAGEAL ATRESIA AND TRACHEO-OESOPHAGEAL FISTULA IN BIRMINGHAM, BY DATE OF BIRTH, 1950-55

| Month | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | Total Cases per Year |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | 1950 | | | | | | ● | | | | | ● | | 2 |
| | 1951 | | | ● | ● | | | | | | | | | 2 |
| | 1952 | | | | | | | ● | | | ● | | | 2 |
| | 1953 | | ● | | | ● | ●●●●● | ● | | | ●●● | | ●●●● | 15 |
| | 1954 | ● | | | | ● | | | ●● | | | ● | | 5 |
| | 1955 | | | | ● | ● | | | ●●● | ● | ● | ● | ● | 9 |
| Total Cases per Month | | 1 | 1 | 1 | 2 | 3 | 6 | 2 | 5 | 1 | 5 | 3 | 5 | 35 |

TABLE IV

OESOPHAGEAL ATRESIA AND TRACHEO-OESOPHAGEAL FISTULA IN THE NEWCASTLE REGION, BY DATE OF BIRTH, 1950-58

| Month | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | Total Cases per Year |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | 1950 | | ● | | | | | | | | | | | 1 |
| | 1951 | ●● | ● | | | ● | ● | | ● | | | ●● | | 8 |
| | 1952 | | | | | | | | | | | ● | | 1 |
| | 1953 | | ● | | | | | ●● | ● | | | | | 4 |
| | 1954 | | | | | | | | | ●● | | ● | | 3 |
| | 1955 | ●●● | ●●● | ●●● | ● | ● | | ●● | | ● | ● | ● | | 16 |
| | 1956 | ●● | | ● | | ●●●● | | ● | | ● | | ● | ● | 11 |
| | 1957 | | ● | ● | | ●● | | | ● | ● | ● | | | 7 |
| | 1958 | ● | | | | ●● | ●●● | | ● | ●● | ● | ● | ● | 12 |
| Total Cases per Month | | 8 | 7 | 5 | 1 | 10 | 4 | 5 | 4 | 7 | 3 | 7 | 2 | 63 |

within successive arbitrary equal periods of time after index cases. Each case is used in turn as the index. Because all "secondary" cases in the appropriate periods are counted, not just the first subsequent ones, the distribution expected in a random distribution is rectangular and not exponential. Thus we expect the sum of cases occurring in the period 0 to 6 days after the index cases to be the same as those occurring in each of the periods 7 to 13 days, 14 to 20 days, and so on. Furthermore, we can easily calculate the expected number for each period from the total number of cases seen and the total period covered. Results of such counts and calculations are given in Table V (opposite). They seem to show that within 2 and possibly 4 weeks of a case there was an increased risk of another, but that this was not evident after 4 weeks. This degree of concentration suggests an oscillation of shorter period than that due to the trend in the completeness of ascertainment, and there were no systematic seasonal variations which could have supplied an oscillation of this type.

While this technique of presentation supplies an adequate descriptive statistic in these circumstances, it presents unfortunate difficulties in relation to possible tests of significance. Regarded as Poisson terms, the totals for each of the first subsequent 3 weeks in the Birmingham series, and both the first week and first fortnight in the Newcastle series, could be regarded as significantly high. But it is not obvious that the events can be regarded as independent when the counts are made in this way and some, clearly, are counted more than once. The same difficulties apply to the $\chi^2$ test.

Returning to the exponentially distributed lengths of intervals between *successive* cases, we can calculate, from the mean interval and by reference to a table of exponential functions, the number of intervals of less than 2 weeks which we should expect to observe at both Birmingham and Newcastle under conditions of randomly occurring events. The mean interval ($\bar{t}$) at Newcastle was 52·17 days,

TABLE V

NUMBER OF CASES OF OESOPHAGEAL ATRESIA/TRACHEO-OESOPHAGEAL FISTULA OCCURRING IN SUCCESSIVE WEEKS AFTER INDEX CASES

| Number of Days After Index Case | | | 0–6 | 7–13 | 14–20 | 21–27 | 28–41 |
|---|---|---|---|---|---|---|---|
| Length of Interval (days) | | | 7 | 7 | 7 | 7 | 14 |
| No. of Cases | Newcastle | Observed | 15 | 12 | 6 | 12 | 18 |
| | | Expected* | 8·3 | 8·3 | 8·3 | 8·3 | 16·6 |
| | Birmingham | Observed | 10 | 8 | 9 | 5 | 7 |
| | | Expected* | 3·8 | 3·8 | 3·8 | 3·8 | 7·6 |
| | Total | Observed | 25 | 20 | 15 | 17 | 25 |
| | | Expected | 12·1 | 12·1 | 12·1 | 12·1 | 24·2 |
| | | Excess as percentage of Expected | 107 | 65 | 24 | 40 | 3 |

* "Expected" values calculated by supposing the time series to be circular.

Thus the expected value for 7 days, following one case, in Newcastle is $\frac{62 \times 7}{3,287}$, and, following 63 index cases, it is $\frac{62 \times 63 \times 7}{3,287}$.

For Birmingham the expected value is $\frac{34 \times 35 \times 7}{2,191}$.

The actual values were also calculated by presuming that the series was circular.

and at Birmingham 62·60 days (the series being supposed as annular for the purpose), so that 2 weeks represents 0·268 $\bar{t}$ at Newcastle and 0·224 $\bar{t}$ at Birmingham. From this, we expect 0·237 of the intervals at Newcastle (*i.e.* 14·9) and 0·206 of intervals at Birmingham (*i.e.* 7·2) to be in the range 0–13 days. The observed figures (see Tables I and II) were 22 at Newcastle and 12 at Birmingham: a total of 34 against an expected 22·1. This is a significant excess.

However, although it is legitimate here to regard the figures as Poissonian variables, this approach is somewhat arbitrary and depends upon selection of an interval after inspecting the data, and in any case does not distinguish clearly between clustering and trend. The same objections apply to most other *ad hoc* techniques.

## DISCUSSION

The first regrettable conclusion is that direct attempts to approach the question of clustering are fraught with difficulties which permit only indirect inferences.

Thus, it can be shown satisfactorily that the distributions are not random in time, and that there are significant irregularities about linear trends, while the nature of the distributions does not suggest that more complex trends in improvement in diagnosis or ascertainment could supply a full explanation. Secondly, appropriate means of analysis provide a picture which strongly suggests the occurrence of short-term clustering on repeated irregularly-spaced occasions and the absence of a systematic seasonal variation. These methods are not obviously susceptible to direct tests of significance.

It is surprising that there are no established general criteria of epidemicity, yet this seems indeed to be the case. However, if we make the presumption that there are probably no sources of variation here, other than more or less linear trends in the completeness of ascertainment or in the population at risk, and a possible tendency towards epidemicity, we could permissibly infer from the results that tracheo-oesophageal fistula (and/or congenital atresia of the oesophagus) is an epidemic disease. This is admittedly an oblique approach, but available methods seem to offer no alternatives and, in so far as the presumptions are reasonable, the conclusion likewise is reasonable.

The possible mechanism is a separate question and one which has not yet been investigated. The only matter of concern here is the question of artefact, in particular whether the occurrence of one case could so improve diagnosis in the ensuing weeks as to cause a temporary improvement in the likelihood of diagnosis of the next case. On *a priori* grounds it would seem unlikely that such an improvement could be so temporary, but there was also some evidence from the addresses of these children. There were in fact no close groups in time which were also close in space or which were born in the same hospital; in short, there was no evidence from direct examination that the individual doctors or midwives responsible for the initial diagnosis or investigation ever had closely repeated situations of this kind thrust upon them.

It seems far more likely that the clustering is a true biological phenomenon and analogy with the maternal rubella phenomenon would suggest infective origins.

## SUMMARY

The question of clustering of events in time is discussed in relation to the occurrence at Birmingham and at Newcastle of tracheo-oesophageal fistula and/or oesophageal atresia.

Attempts are made to apply direct critical tests for epidemicity, but an oblique approach is finally used to reach the conclusion that true clustering occurs.

It is suggested that the disease may have an infective origin similar to that of the congenital malformations which have been seen to follow maternal rubella.

Besides many colleagues in the two departments in which this work was done, I wish to thank especially Professor J. M. Smellie, Mr. G. A. Mason, Dr. J. M. Stansfeld, and Dr. G. A. Anderson for help in tracing material. The first part of this work was carried out during the tenure of a Medical Research Council Clinical Research Fellowship.

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*Single Number* 17s. 6d.

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Publishing Manager, B.M.A. House, Tavistock Square, London, W.C.1